Are Returns to R&D in the Global Services Industry Impervious to Business Environment Turbulence?

It was the best of times, it was the worst of times…

—Charles Dickens (1895)

We investigate firm, industry and country variations in changes of returns to R&D after the global financial crisis in the global services industry. To conduct this exploratory work, we use a large panel data sample of 11,635 company-years from 82 countries for the period 2003-2013. We find that services firms, after the crisis, (1) can derive better returns from R&D, and (2) the changing returns to R&D could be contingent on firm-specific idiosyncrasies, general industrial environments, and national institutional quality. Our results find support in both the exogenous shock model and Schumpeterian theories, but only to an extent, thus demonstrating the need for further theorization on the influence of R&D on a firm's performance in the post-crisis period. We address the question of whether returns to R&D in the services industry are impervious to business environment turbulence. We find that they are not, though persistence in R&D, contingent on the firm, industry, and country-level factors, could be crucial for their performance. Notably, low market share, high leverage, stability in the services sub-industries, and sound national institutional quality might be important to derive returns from innovative activities.

Keywords: global financial crisis; R&D; growth; services industry; cross-country differences; industry effects

INTRODUCTION

"A difficult economic environment argues for the need to innovate more, not pull back." says American Express CEO, Ken Chenault. Historically, firms' reaction to business environment turbulence has often been defensive and reactive, but not proactive, and their strategic leaders repeatedly prioritize short-term actions over longer-term initiatives (Gulati, Nohria, & Wohlgezogen, 2010; Reeves, Rhodes, & Whitaker, 2019). As a result, spending on research and development (R&D) has often been delayed or simply canceled. However, American Express, as one of America's most admired companies, acted counterintuitively during the global financial crisis (GFC). Chenault and his C-team made a heavy investment in R&D activities, such as embracing digital technology and searching for new partnerships. In 2007, Chenault even established a $50 million innovation fund to finance all employees' creative ideas for transforming American Express' global business in the long term. These strategic R&D investment projects eventually led to a more than tenfold jump in the stock price compared to the level prior to the GFC (Reeves et al., 2019). Reflecting on the case of American Express, is the extent to which investing in R&D a generalizable strategic choice for many business leaders in the services industry during times of crisis, or is it simply an anecdote about a particular giant? To address this concern, a general research question remains: *Is there an association between returns to R&D in the services industry and business environment turbulence?*

A strand of the literature views an economic crisis as an exogenous shock that brings hardship to firms' R&D and innovation (e.g., Barlevy, 2005; Srinivasan, Lilien, & Sridhar, 2011). Although these studies provide an insight into the impact of the crisis on firms' R&D, it is argued that various industries such as manufacturing, services, and trade may not react to a crisis in the same manner (Chung, Lee, Beamish, & Isobe, 2010; OECD, 2012). Firms in services industries suffer more from severe vulnerability to crisis due to the nature of services that require intensive interdependency between their different elements, such as customers'

behavior and attitudinal changes because of a lack of market confidence (Kim, Lado, & Torres, 2009). Following a macroeconomic shock, firms' R&D expenditure and the returns from it fall during a crisis. Only firms that access external support or develop unique capabilities can show persistence in R&D (Arvanitis & Woerter, 2013; Filippetti & Archibugi, 2011; McAlister, Srinivasan, & Kim, 2007; Paunov, 2012).

Conversely, another important research strand states that innovation drives economic cycles and is reshaped by economic crises (Schumpeter, 1939). Given that economic crises can provide a fertile environment for R&D, this line of research predicts a counter-cyclical investment in R&D for the global services industry (e.g., Arvanitis & Woerter, 2013; Filippetti & Archibugi, 2011; Lee, Sameen, & Cowling, 2015). In the Schumpeterian context (Schumpeter, 1911, 1942), the services industry is a key player in driving innovation in processes and services, supporting innovation in product-based sectors. The last two decades have shown some clear evidence that services are indeed innovative and, in some sub-sectors, more innovative than manufacturing (Durst, Mention, & Poutanen, 2015). In addition, according to the Clark-Fisher structural change hypothesis, economic development will eventually lead to the majority of the labor force working in the services sector (Barber & Strack, 2005).

Embracing the inconsistent and competing strands of arguments on the influence on services firms of investing in R&D during crises, we aim to explore the R&D–performance relationship, contingent on firm-, industry- and country-level characteristics. In terms of the firm-level characteristics of these services firms, we look specifically at their market share and financial leverage. Further, we consider the dynamism of the business environment from the industry perspective and its implications for R&D's effects on performance. Lastly, our examination of this phenomenon also addresses the country-level differences in R&D investment and performance in the post-crisis period by looking at national institutional

quality. Studies show that countries are endowed with different capabilities and, as such, will have varied capacity and resources for addressing the issues emerging from an economic crisis (Hall & Soskice, 2001; Whitley, 2007). Countries might also be in different phases of their business cycle and with limited or no links with the global business cycle, and thus, they experience differing impacts of an economic crisis at the country level.

In view of our exploratory questions on this phenomenon and with the aim of advancing knowledge via discovery through empirical analysis (Van de Ven, 2017), our study employs a large panel dataset of 11,635 company-years from 82 countries for the period 2003-2013. The countries in our analysis include both advanced countries (e.g., the United States, United Kingdom, and Australia) and developing countries, such as BRICS economies (Brazil, Russia, India, China, and South Africa). These show substantial variations in terms of firms' development and R&D investments. Based on the data, we consistently find that firms may benefit more from R&D investments for firm growth after the crisis. We further show that the change in the performance effect of R&D after the crisis is contingent on firm-specific idiosyncrasies, industrial dynamism, and national institutional quality.

From the theoretical perspective, our work provides an outline of contingencies that determine the nuances of the underlying theories and provides insights into various determinants and constraints that might strengthen the generalizability of results based on these theories. For the exogenous shock model, we observe that this theoretical view needs to extend beyond its focus on external support and incorporate within its boundaries firm-level resources and macro national institutions, since our study finds the association of these factors with R&D and performance. From the Schumpeterian model, we should extend this view beyond that of firm-level resources and industrial dynamism and consider the effects of macro national institutions.

R&D IN THE SERVICES INDUSTRY

Services Firms and R&D Activities

The importance of the services industry cannot be understated. In advanced economies like the OECD countries, the services industry accounts for almost two-thirds of value-added activities, and, compared to the manufacturing sector, the share of this sector in economic performance continues to grow (Kox, 2002). According to a report from the WTO, the services sector accounts for over 70% of global GDP and has been increasing at a higher rate than other sectors for several years (Lanz & Maurer, 2015). The traditional view conceives of the services sectors, compared with the manufacturing branch of the economy, to be less invested in terms of R&D and innovation, partly because of the intangible and inseparable nature of services (Kox, 2002). First, while entry barriers to product innovation are considerably lower than exit barriers in the manufacturing sector, the opposite turns out to be true for services firms (Hecker & Ganter, 2014). That is, compared with manufacturing firms, services firms face more challenges in introducing product innovation. Second, services tend to have an intangible existence that cannot be inventoried accurately and reproduced easily (Berthon, Pitt, Katsikeas, & Berthon, 1999). This means that services innovation can be readily imitated and improved because its intellectual property is insufficiently protected (Tufano, 1989). As a result, services firms gain less from pioneering new offerings (Song, Benedetto, & Zhao, 1999). Third, services are usually produced, delivered, and consumed simultaneously through close interaction with customers (Berthon et al., 1999). In this sense, services cannot be easily standardized since they are adapted to satisfy the changing and differentiated demands of customers. This makes it hard for a services firm to achieve scale economies for obtaining sufficient returns from innovation.

At the same time, during the last decade, the research on innovation in the services sector has grown considerably (Den Hertog, 2000), and it has been recognized that services firms are no longer just recipients of manufacturing innovations. Recent years have witnessed the rapid progress of services innovation and growing interdependence between

manufacturing and services sectors (e.g., Castellacci, 2008). Due to technological innovations, services firms can rely on video and teleconferencing to communicate with customers; services are standardized and inventoried to reach a wider range of markets; the upstream value chain is centralized so that scale economies can be realized (Capar & Kotabe, 2003). Consequently, contemporary services firms are profiting more from R&D and innovation compared to firms in this industry in the past.

The services industry is highly diverse. There are several industries, like hotel management services, where the services are mostly low-valued-added operations, hence, the intellectual contribution is not important, and investment in innovation is limited (Barber & Strack, 2005). In contrast, we have high-tech services industries, such as software and information technology industries, which require consistent investment in R&D (Coad & Rao, 2008). Studies have emerged which show different classifications for services firms, taking into account the differences in R&D investment across various services sub-industries (e.g., Kellogg & Nie, 1995). Given this, services firms experience differing levels of competition and uncertainty at the services sub-industry level. Such unpredictable change and instability construct a dynamic industry-level environment for firms considering their investment decisions on innovation (Brauer & Wiersema, 2012). This argument is challenged by Hipp and Grupp (2005), who suggest that the patterns of innovation in services depend to a lesser degree on the variance of industrial dynamics of services firms.

The country-level differences have also been observed in this industry because some countries are more likely to benefit from the inherent location advantages such as better market structure, human capital, access to finance, historical legacy, etc. (e.g., Hotho, 2014), and thus have a higher tendency to invest in R&D to further leverage these location advantages. We observe that OECD countries are more geared towards the services industry

because much of their economy has replaced the dominance of agricultural and manufacturing sectors with growth in services (Dall'erba, Percoco, & Piras, 2009).

Services Firms and R&D Activities under Adverse Economic Conditions

Studies have shown that the services industry has been able to mitigate the negative effects of the financial crisis (Borchert & Mattoo, 2009). Yet evidence has emerged across the world, which shows that services firms from different countries experience different effects from a financial crisis. In Australia, it was reported that retail services experienced increased competition due to the effects of the GFC (ICN, 2012). Despite the global economic downturn, U.S. firms continued to export key services internationally, and their exports continued to grow (Borchert & Mattoo, 2009). In the case of countries like India, their exports in the services industry continued to grow during this period, and much of this growth was driven by the firm- and country-level capabilities; since many of these large services firms were debt-free, their internal cash flow was sufficient to cover working capital, and government also continued to support relatively free access to global markets (Borchert & Mattoo, 2009). Thus, based on the intrinsic strength of their domestic economic systems, countries have experienced the effect of the financial crisis differently.

Filippetti and Archibugi (2011) examine the impact of the 2008 GFC on European firms' innovation activities and suggest that national settings have a great influence on firms' ability to absorb synergies from the financial crisis, including the creation of new products and services, and that national structural conditions are a precursor to firms' engagement with the global crisis. They argue, further, that the degree of industrial specialization in the country can greatly affect the firms' ability to manage the global crisis as well as changes in demand.

THEORIES AND THEIR PREDICTIONS

The Exogenous Shock Model

The exogenous shock model treats an economic crisis as an exogenous shock to innovation systems and primarily focuses on the difficulties facing firm R&D activities during a crisis.

Such difficulties include contracted demand for goods and services, impeded international trade, increased uncertainty, and decreased liquidity and profits (Barlevy, 2005; Geroski & Walters, 1995; OECD, 2009, 2012; Paunov, 2012; Srinivasan et al., 2011). Since the payoffs from innovation are perceived to be low in this situation, R&D projects become a dispensable luxury and come under close scrutiny. Firms have a propensity to cut R&D expenditure in order to control costs and maintain liquidity.

This line of research has straightforward predictions for firms' R&D behavior, and its R&D during a crisis that has received consistent support in various empirical contexts (for a recent review, see OECD, 2012). We can further infer that, in the long run, the negative impact of a crisis cannot be ignored because it hurts firms' innovation capacities. If some firms show persistence in innovation during a crisis, we expect that the negative effect of the economic crisis might be partially offset by the strengths of the national innovation system (Filippetti & Archibugi, 2011), the availability of external finance (Paunov, 2012) or a firm's efficiency and flexibility accumulated from previous R&D investments (McAlister et al., 2007), and firm-level non-R&D resources such as customer loyalty (Srinivasan et al., 2011).

From this discussion, it can also be posited that we can observe country-level differences in R&D investment and firm performance (Nelson & Nelson, 2002). In difficult economic situations following a crisis, country-level resources that can circumvent the negative effects of a global economic crisis might be deployed by state actors to mitigate the negative influence of the crisis (Filippetti & Archibugi, 2011). These national institutions not only provide 'flavor' to country-level institutions, but they also demonstrate nations' ability to manage the change (Fan, Li, & Chen, 2017; Hall & Soskice, 2001). The business systems might differ in various countries, and thus have different capacity to manage and absorb uncertainties. For example, countries that are more dependent on external capital will experience higher turbulence during the crisis (Braun & Larrain, 2005). Thus, although

exogenous shock might reduce firms' R&D, there are equally several potential reasons for why R&D investment might be continued by firms, as well as reasons why firms will benefit from this continued R&D during the crisis.

The Schumpeterian Business Cycle Model

Assuming that innovation is the fundamental source of economic fluctuation, Schumpeter (1939) takes a more positive view of the impact of economic crises on firms' R&D, in that economic crises have virtues for innovation because they correct for inefficiencies and strengthen firms' focus on their productivity-enhancing agenda. Some firms may invest heavily in R&D to take advantage of crises to strengthen their market position. Based on Schumpeter's model, we expect a counter-cyclical investment in R&D and innovation; that is, the effect of a crisis on R&D is negligible or even positive. Although the pro-cyclicality of R&D is prominent with respect to the GFC (OECD, 2012), the extant literature does show some counter-cyclical R&D behavior, e.g., more than half the firms in a recent interview series claimed to have maintained or increased their levels of R&D investments in the post-crisis period (Arvanitis & Woerter, 2013).

Another important prediction of Schumpeter's model concerns the innovation model behind the crisis. In the Schumpeterian Mark I model, the crisis goes through a process of creative destruction, during which a radical breakthrough is introduced by entrepreneurs, and this creates a new technological trajectory (Schumpeter, 1911). In the Schumpeterian Mark II model, the crisis is characterized by a high level of technological cumulativeness, during which innovations are concentrated in the hands of established firms (Schumpeter, 1942). Taken together, the dominant innovation model determines the patterns of crises and which types of firms and countries can survive them.

Based on these arguments, we argue that country-level differences can influence R&D investment and related firm performance. For example, in some cases such as high-income countries, lending by state banks is counter-cyclic, implying that these banks expand their

credit relatively more during crises (Filippetti & Archibugi, 2011). Thus, in this situation, firms might find it easier to gain access to the required capital to invest in their R&D activities and capture emerging consumption patterns during the crisis. Based on the two theories above, and their indications as to what might happen with regard to R&D and firms' performance following the crisis, we derive our first research question:

Research question (RQ1): Does R&D investment have a positive relationship with firm performance in the services industry following the crisis?

MARKET SHARE AND R&D AFTER THE CRISIS

The relationship between market share and R&D has been widely studied in innovation research, with different models of crisis having varied focuses and predictions regarding the effect of market share on R&D with respect to an economic crisis. The exogenous shock model focuses on how a greater market share facilitates firms' R&D activities during a crisis. Given the hard times experienced during a crisis, a greater market share helps firms to achieve economies of scale in their R&D programs and reap benefits from them (e.g., Arvanitis & Woerter, 2013; Boddewyn, Halbrich, & Perry, 1986; Srinivasan et al., 2011). On the demand side, firms with a greater market share are perceived to survive a crisis and to be more likely to win over customers (Pearce & Michael, 2006). For services firms, economies of scale can be generated by developing process and services which reduce the cost of delivery of the services as well as create opportunities for easy scaling of these services. For example, as consumers redefine their spending following the crisis, tourism firms that offer package tours might redesign their services so that consumers can pick and choose items that they add to their package based on their budget.

According to the Schumpeterian business cycle model, the effect of a market share depends on whether the creative destruction or accumulation model of innovation dominates the crisis. If the former dominates, entrepreneurs play a fundamental role in innovative activities and challenge established firms; if the latter dominates, large oligopolistic

corporations are more capable of conducting R&D as a routine. The extant literature provides evidence of the simultaneous presence of both creative destruction and accumulation in the current crisis (e.g., Archibugi, Filippetti, & Frenz, 2013). Taking the same example of tourism firms, a crisis can create opportunities for smaller, niche firms to attract consumers with offerings geared to addressing emergent consumer spending patterns following the crisis and, at the same time, larger and established tourism firms, due to the scale of their operations, can springboard via innovations that reduce operational and delivery costs.

Studies have shown that some form of oligopoly emerges after the crisis that restricts competition and allows long-term technology investment (Perez, 2010). Woerter (2014) finds that persistence of R&D investments is more likely to be observed in markets with few principal competitors (between six and ten) but not in polypolistic market types. The services firms with large market share (oligopolistic firms) are more likely to take advantage of R&D expenditure during this crisis period. An OECD report (2012) also shows that the crisis rewarded large, high-technology, innovating services firms. This leads to the next research question:

Research question (RQ2): Is there a difference between the high-market-share firms' and low-market-share firms' returns to R&D in the services industry after the crisis?

FINANCIAL LEVERAGE AND R&D AFTER A CRISIS

Financial leverage, defined as the use of debt to acquire additional assets (Jensen & Meckling, 1976), has been identified as critical for understanding firms' R&D and innovation in the extant literature. Yet the basic assumption about how financial leverage affects firms' R&D differs according to two different perspectives. One view conceives greater financial leverage as a disadvantageous condition that exposes firms to the negative effects of an economic crisis on R&D activities. During a crisis, banks, venture capitalists, and personal investors become risk-averse and are reluctant to lend or invest money. As a result, firms have difficulty financing R&D and services innovation, with long-term, risky projects being

cut before returns are realized. In the case of highly leveraged firms, access to finance may even be impaired.

The extant literature provides evidence that innovation is negatively affected by a lack of finance (OECD, 2012). The availability of internal finance is another way in which firms fight an economic crisis and leverage their R&D investments (Lee et al., 2015). Given this logic, we would expect that greater financial leverage exaggerates capital constraints upon firms during a crisis and therefore prevents them from benefiting from R&D.

Another view of financial leverage and firms' R&D derives from the agency theoretical argument that self-interested managers seek to maximize their utility at the expense of corporate shareholders (Jensen, 1986). From this perspective, R&D expenditure carries a risk of overinvestment as a form of a free cash flow agency problem. The uncertain nature of R&D brings about the information asymmetry problem, which makes it difficult for shareholders to value R&D projects. Financial leverage can act as a monitoring mechanism by lenders to prevent overinvestment (e.g., Jensen, 1986), thereby enhancing returns to R&D.

In the crisis scenario, only firms with special access to capital will be less affected by an economic crisis. For example, Paunov (2012) finds that firms with external sources of funding are more persistent in the case of R&D projects. From the above discussion, it can be seen that the financial leverage of a firm can be its weakness; at the same time, we argue that in the period following the crisis, financial leverage, which represents a firm's ability to generate external finance, also represents the market sentiment on the capability of these firms. Thus, firms that can continue to borrow money from the market represent firms, which lenders believe, are expected to do better following the crisis. Thus, we seek answers to address:

Research question (RQ3): Are the returns to R&D in the services industry less for high-leverage firms as compared to low-leverage firms after the crisis?

INDUSTRY CONTINGENCIES AND R&D AFTER A CRISIS

Industrial competitive dynamics affect firms' willingness to take on additional challenges for conducting R&D activities, which further their performance (Chen & Miller, 2012). To account for industry factors, we focus on a particular industry-related environmental condition—industrial dynamism. Industrial dynamism refers to the rate of change and degree of instability of the industrial environment. A dynamic industry is characterized by uncertainty resulting from rapid industry growth, frequent technological developments, constantly redefined market/customer demands, shifting of competitive tactics, or mounting competition pressure from other countries (Jansen, Van Den Bosch, & Volberda, 2006). These may create problems for those firms that cannot refit their strategy to become adaptable to dynamic environmental changes in a timely manner (Lumpkin & Dess, 1995), and they challenge firms' adaptability (Luo & Tan, 1998).

Prior research has suggested that a dynamic industry environment may influence firms' strategy-making process, strategy execution, and performance (e.g., Brauer & Wiersema, 2012; Lumpkin & Dess, 1995). Scholars also proposed that the dynamic environment may moderate the strategy-performance relationship (Miller & Chen, 1996). That is, a strategy that relies on established routines and practices, or draws on a restricted competitive market, may be ineffective in a highly dynamic environment that requires responsiveness and flexibility (Luo & Tan, 1998). Compared with a stable industry environment, a dynamic industry environment requires firms to summon a large set of competitive tactics, make greater efforts in innovation, and generate new appropriate strategies (Lumpkin & Dess, 1995). However, when services firms also face mega-economic challenges, such as the GFC, and specific industry challenges (e.g., a rapidly developing industry environment), their light-asset, low-debt, or debt-free features may mitigate these advantages and make it difficult persuading banks or other financial institutions to make loans or financially invest in their R&D activities, which would, in turn, reduce their financial return after crisis (cf. Judge &

Zeithaml, 1992). On the other hand, agile services firms can benefit from the dynamic environment during the crisis by focusing their R&D on a few key projects, and they can deploy capabilities and services effectively to match industry dynamism. However, the extent to which industry dynamism affects services firms' adaptability or rigidity that further leads to their strategic choice requires investigation. Thus we explore this question:

Research question (RQ4): Are the returns to R&D for firms in a highly dynamic services industry less than for firms in a more stable services industry after the crisis?

NATIONAL INSTITUTIONAL QUALITY AND R&D AFTER THE CRISIS

Prior studies in national business or innovation systems conclude that various institutional varieties collectively produce distinct ways of economic coordination that can shape the patterns or characteristics of their R&D activities (Hotho, 2014). Along with the economic development trend, it has been observed that institutional settings among service-economy-dominated societies are inclined to support services innovation and employment (e.g., Hipp & Grupp, 2005). While comparative institutionalists predominantly focus on the comparison of one institutional environment with another (Hall & Soskice, 2001; Whitley, 2007), researchers find that even two countries with similar institutional settings do not match one another in the level of innovation performance. That is, country-level differences in the effect of R&D investment and firm performance lead us to argue that there are potential country-level institutional effects (Hall & Soskice, 2001), such as a differential effect of cultural and institutional varieties (Fan et al., 2017), domestic business environment effects (Hall & Soskice, 2001) and foreign trade (Giovanni & Levchenko, 2010), which might exacerbate or mitigate the issues arising from a global crisis.

Moreover, compared with well-established market-driven institutional systems in most advanced economies, emerging economies are considered to have institutional voids, such as lack of protection of intellectual property rights, opaque judicial proceedings, inefficient market intermediaries, and inefficient policy implementation capacity (Khanna &

Palepu, 1997). Through a comparative study of national innovation performance among all OECD countries before and after the GFC, Fan et al. (2017) posit that a country can adjust or develop institutional conditions to maintain or create leadership in innovation. This is entirely possible from an institutional work perspective, which argues that actors work to create, maintain, and disrupt institutions (Zietsma & Lawrence, 2010). However, not all countries or societies can recognize the importance of conducting institutional work, nor do they have the ability to adjust their business cycles to fit with global business environmental changes. Thus we can observe that some countries need to adjust their institutional arrangements to sustain their competitive position in innovation performance in services sectors while others do not need to do so (cf. Hipp & Grupp, 2005). In addition, an institutional environment only predisposes an economy to specialize in one type of innovation but does not necessarily guarantee the production of such innovation (Akkermans, Castaldi, & Los, 2009; Fan et al. 2017). All these suggest that the consequences of differing institutional environments across countries are not universal and may depend on the complementarity of institutions or domestic business cycles (Whitley, 2007). In line with these arguments, we propose the following research question:

Research question (RQ5): Are there country-level institutional quality differences in the returns to R&D in the services industry following the crisis?

METHODOLOGY

Data

To address these RQs, we collect multiple-level data from two sources. One source is the micro-database, BvD (Bureau van Dijk Electronic Publishing) Osiris, which collects financial and operational information for publicly traded firms across countries from balance sheets and income statements, together with detailed information on firms' domestic and international ownership structure for 80,000 companies across the world. The BvD Osiris data is available for firms in 141 countries, but the time periods are inconsistent. BvD Osiris

is one of the most commonly used data sources in studying corporate finance (e.g., Blanco, Lara, & Tribo, 2015; Lara, Osma, Mora, & Scapin, 2017) and firms' internationalization decisions (e.g., Albino-Pimentel, Dussauge, & Shaver, 2018). Wide coverage of listed firms over time, along with detailed information, facilitates longitudinal, cross-country studies of firms' strategy and performance. In addition, to collect country-level data, we link the country where a particular firm is located to the other data source – Worldwide Governance Indicators (WGI), developed by the World Bank (Kaufmann, Kraay, & Mastruzzi, 2011).

We employ a set of criteria to derive data from the database. First, we drop firms in abnormal operation (i.e., those that went bankrupt, dissolved, acquired or had an age less than zero) because they might have different R&D patterns and performance outcomes (e.g., Chang & Singh, 1999). Second, due to our focus on services R&D, we restrict our sample to firms with the two-digit Standard Industrial Code (SIC) code 70-89[1]. In prior studies, the SIC codes are commonly used to distinguish services industries from manufacturing (e.g., Hogan & Jeter, 1999). Third, we exclude any industry with fewer than 100 firms over ten years. Since we need to build an industry-level moderator, too few observations may create estimation bias. The exclusion of unrepresentative industries is comparable to McGahan and Porter's (1997) exclusion of single-year appearance and small segment firms. Fourth, we conduct a cleaning procedure by dropping firms with incomplete or with abnormal observation information for the variables of interest (i.e., total assets, employment, or sales are negative) (Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych, & Yesiltas, 2015). These procedures finally yielded a sample of 4202 firms from 82 countries and an unbalanced panel with 11,635 observations (firm-years) from 2003 to 2013, with the year 2008 excluded.

[1] SIC code 70-89 commonly refers to a comprehensive range of services sub-industries, including hospitality management, personal, business, automotive, miscellaneous repair, motion pictures, amusement and recreation, health, legal, educational, social, museums, membership organizations, engineering, finance and banking, private households and other miscellaneous services.

Table 1 provides the details of the countries included. The Japanese dataset is the most comprehensive, covering 785 firms with 2,332 observations from 2003 to 2013, followed by the U.S. dataset (454 firms with 2,211 observations). The average R&D intensity for the U.S. firms is 0.380, far above those for firms from the other countries. One should be mindful that our sample of listed services firms contains a high percentage of large-sized firms with numbers of employees higher than 250. The sample services firm percentage in the BvD Osiris for the ten-year period, which ranges from 0.082 to 0.758. Finally, Malaysia, Indonesia, Singapore, Thailand, and Italy are exceptional cases with missing annual information of firms, resulting from missing values of key variables of our research.

[Insert Table 1 about here]

Measures

Performance. The dependent variable, firm performance, is measured by sales growth, computed as the change in logged sales over the previous year (Hall, Mairesse, & Mohnen, 2010). Sales growth is commonly used to measure performance in R&D and innovation research (e.g., Coad & Rao, 2008; García-Manjón & Romero-Merino, 2012). Early in 1965, Scherer (1965) finds that innovation does not increase profit margins, but does increase sales at a constant profit margin. This suggests that sales growth is particularly meaningful compared to other indicators in this line of research (Thornhill, 2006).

***R&D intensity*.** We focus on R&D intensity as the independent variable, which is the most commonly seen in R&D and innovation studies (Cohen & Levinthal, 1989; Dosi, 1988). In prior studies, R&D intensity is calculated as R&D expenditure normalized by sales, employment, or total assets (Kor, 2006). Since we follow Hall et al.'s (2010) model to assess returns to R&D, we measure R&D intensity by dividing R&D expenditure by net sales.

***Firm characteristics*.** We measure market share as a firm's sales divided by the total sales of all sample firms in the firm's primary three-digit SIC code. For financial leverage, we calculate this as the ratio of a firm's total debt to its total assets (Jensen & Meckling, 1976).

In prior studies, debt is used as a proxy of capital structure that affects a firm's investment decisions (Myers, 1977).

Industry dynamism. There are three commonly used approaches to standardizing scores for calculating industry dynamism: mean standardization, log standardization, and unstandardized scores (e.g., Boyd & Gove, 2006). We follow Keats and Hitt (1988) and Datta, Guthrie, and Wright (2005) to calculate the measures of industry dynamism of the specific country. We regress the natural logarithm of sales for each three-digit local industry for three years against time. The dynamism measure of each local industry is the antilog of the standard errors of the slope regression coefficients from each model. Higher standard errors indicate greater volatility of industry sales growth rates. The basic equation for these indicators is given by

$$y_t = b_0 + b_1 t + a_t \qquad (1),$$

where *y* is the natural logarithm of industry sales, *t* is time, and a is the residual.

National institutional quality. Previous strategy and international business (IB) studies adopt the WGI to measure national institutional quality (e.g., Cuervo-Cazurra & Genc, 2008; Gözübüyük, Kock, & Ünal, 2020; Lu, Liu, Wright, & Filatotchev, 2014). The WGI consists of six measures (i.e., voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption) (Kaufmann et al., 2011). Strategy and IB scholars use WGI in various ways to serve their research purposes. Some studies consider six sub-indices as different dimensions of national institutional quality and include them in one regression model (e.g., Oh & Oetzel, 2011), while others select the sub-indices and create a latent construct (e.g., Damania, Fredriksson, & Mani, 2004; Gözübüyük et al., 2020; Lu et al., 2014).

In line with prior studies (e.g., Bermpei, Kalyvas, & Nguyen, 2018; Damania et al., 2004), we adopt the confirmatory factor analysis method to create a second-order construct—

national institutional quality—which averages the three WGI sub-indices (namely, political stability, rule of law, and control of corruption) with an internal consistency Cronbach's alpha (0.872)[2]. We reason the conceptualization in a two-fold aspect. First, a recent review by Kostova and colleagues (2020: 490) explicitly states that the quality of national institutions is measured by sub-dimensions of WGI, such as, "rule of law, degree of corruption, and strength of political institutions, all of which can be linked to North's ideas of ease of doing business, market-supporting institutions, transactions costs, and uncertainty". Second, some WGI sub-indices focused on perception-based assessment on institutional quality (e.g., government effectiveness; Sugathan & George, 2015), or has the ideology in favor of democratic institutions (e.g., voice and accountability; Gözübüyük et al., 2020). Given 82 countries involved in our analysis, we attempt to remove debatable sub-indices and keep the three sub-indices, which are directly related to reducing transaction cost and uncertainty, and creating opportunities for a seamless business environment for these services firms to do business in the focal country.

Pre- and Post-crisis. Research into the 2008 GFC has not reached a consensus in identifying the crisis starting point. The *Innobarometer 2009* of the European Commission conducted a survey during April 2009 to compare the innovation activities in 2006 and 2008 at the firm level, which have been analyzed in economic crisis studies (e.g., Filippetti & Archibugi, 2011). Kahle and Stulz (2013) consider the last two quarters of 2007 and the first two quarters of 2008 as the first year of the crisis and further distinguish pre- from the post-Lehman period after the crisis started. Accordingly, we distinguish the performance impact of R&D before and after the crisis by choosing the year 2008 as a relevant cutoff. To obtain a clear time frame, we adopt different cutoffs for our research. In our main analyses, we exclude the year 2008 in our time window. The variable, post-crisis, is a dummy coded as 1 if

[2] Due to length, details of the national institutional quality measure are available upon request.

the year is after 2008 and 0 before 2008. We add the year of 2008 in our estimation time-window as a post-crisis year in our robustness check.

Controls. To control the effects of other inputs on firm growth, we follow the Cobb-Douglas production function to treat the physical assets and employees as traditional inputs of labor and physical capital (e.g., Cincera & Veugelers, 2014). In particular, we transform the number of employees and physical assets by the natural log so as to deal with the non-normality problem and then calculate the difference of the log-transformed employees and physical assets between the current year and the previous year. We also include firm age (i.e., number of years since a firm's founding) in our models as a control.

We find quite a number of outliers with regard to R&D intensity. For example, 3.275% of the sample firms in our dataset spend more on R&D than their net sales, with the maximum value of 1345 times sales. We speculate that such firms may be in an abnormal situation, which may bias the results of our study. The literature primarily uses three approaches to deal with the outlier problem: retention, trimming, and winsorizing. So as to reduce the possible effects of the outliers while maintaining the sample size, we choose the winsorizing approach, i.e., to set the data above the 98th percentile set to the 98th percentile in our analysis.

Model

Specifically, we adopt a general version of the Cobb-Douglas production function for analyzing the R&D-performance relationship (Hall et al., 2010):

$$Y_{it} = A_t L_{it}^{\alpha} C_{it}^{\beta} K_{it}^{\gamma} e^{\mu_{it}} \qquad (2),$$

where Y is output measured by net sales, L and C are the inputs of labor and physical capital, K is the knowledge capital, and γ represents the elasticity of output with respect to knowledge capital.

For estimation, both sides are logged, and the model is rearranged as follows:

$$\ln Y_{it} = \eta_i + \lambda_t + \alpha \ln L_{it} + \beta \ln C_{it} + \gamma \ln K_{it} + \mu_{it} \qquad (3).$$

Here Equation (2) is derived based on the assumption that the log of technical progress (*A*) can be written as the sum of a firm-specific effect η_i and a time effect λ_t. Consistent with prior studies (Cincera & Veugelers, 2014), we estimate the production function by the first difference of their logarithms, assuming that the rate of depreciation of R&D capital is close to zero. Since the elasticity of R&D with respect to output is equal to:

$$\gamma = {}^{\partial Y_{it}}/_{\partial K_{it}} . {}^{K_{it}}/_{Y_{it}} = \rho . {}^{K_{it}}/_{Y_{it}} \qquad (4),$$

Equation (3) can be rewritten as:

$$\Delta \ln Y_{it} = \lambda \Delta t + \alpha \Delta \ln L_{it} + \beta \Delta \ln C_{it} + \rho . {}^{R_{it}}/_{Y_{it}} + \varepsilon_{it} \qquad (5),$$

where ρ is the marginal productivity of R&D capital, R is the gross R&D investment and ${}^{R_{it}}/_{Y_{it}}$ is a measure of R&D intensity. A list of variables that possibly influence returns to R&D is also included in the estimation. To investigate the effects of the two- and three-way interaction terms, we create interaction terms by adopting the centering method before multiplication[3]. To avoid some endogeneity issues, all of the variables on the right-hand side are lagged one year in the estimation.

We estimate Equation (5) using a panel fixed-effect model (FE) for the following reasons. First, based on the Breusch-Pagan LM test, the null hypothesis that variances across firms are zero is rejected. This suggests the use of a random-effect regression, rather than an OLS regression. Second, we conduct a Hausman test to see whether we should treat the unobserved individual effects as fixed or random. We find that the null hypothesis is rejected, that is, the fixed effects are correlated with other explanatory variables. Therefore the

[3] In extant studies, centering method has been used for alleviating collinearity problems, and though there has been some critisicm of this methodology (Echambadi & Hess, 2007), we adopt this methodology of mean-centering as some recent studies have alluded to the value of mean centering data (Iacobucci, Schneider, Popovich, & Bakamitos, 2016). Overall, as argued by Hayes (2013), there are benefits associated with interpretability of data from mean centering. As we do not use this methodology for collinearity issue, we argue that similar to its adoption by other works, in our paper it enhances the interpretability of data.

Hausman test suggests that the fixed-effect model is preferred. Thirdly, the fixed-effect models are allowed to adjust for unobserved time-invariant confounders of each firm when estimating the relationship between the crisis and R&D returns. Taken together, we employ the panel fixed-effect model in our main analysis, accompanied by a set of robustness checks.

RESULTS

Descriptive Statistics

To capture the trend after the crisis, we first construct subsamples of services firms according to the four firm-, industry- and country-moderators. Panel A of Table 2 shows how R&D intensity evolves after the crisis. We find that the average R&D intensity steadily decreases after the crisis for the whole sample and most of the subsamples, except for those of high debt and low industry dynamism. On the other hand, the subsamples for low market share, low debt, and low industry dynamism feature higher levels of R&D intensity than their counterparts, whether before or after the crisis. As shown in Panel B of Table 2, firm growth significantly slows down after the crisis for the whole sample as well as for the subsamples; firms with low levels of market share significantly enjoy a higher rate of growth in both pre- and post-crisis periods.

[Insert Table 2 about here]

Tables 3 presents the descriptive statistics for the dependent, independent, and principal control variables. We can observe from the tables that the correlation coefficients among the independent variables are low, indicating that multicollinearity is not a concern.

[Insert Tables 3 about here]

Regression Results

Table 4 shows the results of the fixed-effect panel regressions for firm growth in the examination of RQs 1, 2, 3, 4, and 5. Model 1 is the baseline model that includes all controls, independent variables, and moderating variables. The results show that the estimated rate of returns to R&D for firm growth is statistically significant and positive, and equal to 0.540.

Model 2 adds a two-way interaction term of R&D intensity and post-crisis. Their joint effect is significantly positive for firm growth ($\beta = 0.183$, $p < 0.05$). Models 3 to 10 include four moderating variables individually (i.e., market share, debt, industry dynamism, and national institutional quality), with first adding the two-way interaction terms and then the three-way interaction terms. Models 11 and 12 are the full models that include the four moderators simultaneously. Since we perform White test and Breusch-Pagan test and find heteroscedasticity in our data structure, we use the robust stand error technique to obtain unbiased standard errors of our coefficients. These robust standard errors are presented in the parenthesis throughout the results table.

We test the variant increase of returns to R&D by examining the three-way interaction effects in Model 12. For firm growth, the interaction between R&D intensity in the post-crisis period and market share is significantly negative ($\beta = -0.435$, $p < 0.01$). We see a negative effect only for companies with a large market share; hence it can be inferred that low-market-share firms compared to high-marker-share firms increasingly enjoy better returns to R&D after the crisis. We find empirical support for the positive interaction between R&D intensity after the crisis and debt with regard to firm growth ($\beta = 0.424$, $p < 0.1$). In other words, high-leveraged firms may enjoy a higher level of returns to R&D after the crisis. The coefficient for the three-way interaction term of R&D after the crisis and industry dynamism is significantly negative ($\beta = -0.926$, $p < 0.01$). That being said, returns to R&D decrease after the crisis in dynamic industries compared to those in stable ones. For national institutional quality, the coefficient for the three-way interaction term has a positive and significant sign ($\beta = 0.666$, $p < 0.1$), suggesting that good quality of national institutions can help firms reap returns to R&D in the post-crisis period. In summary, our results show that returns to R&D increase after the crisis, and the magnitude of these increases are contingent upon firms' market share and debt, industry dynamism, and national institutional quality.

In addition, we performed a series of robustness checks, including, using firms with positive equity, using firms with more than 250 employees, using firms whose age is higher than three years, excluding firm age as a control variable, excluding regions with less than 100 observations, adding the year 2008 into the time-window, using the perpetual inventory method, measuring the dependent variable by firm profits, and adding time, sector and country dummies. Overall, these analyses confirm that our results are robust (for details please see Appendix A-Robustness Tests[4]).

[Insert Table 4 about here]

DISCUSSION

By tracing an evolving R&D-performance relationship together with the economic cycle, our study discovers several intriguing patterns that can contribute to innovation and strategy research. Several streams of research emphasize the effect of economic crises on firms' R&D and innovation: among these, the exogenous shock model argues that an abrupt economic crisis is an exogenous shock to all firm R&D activities, but the Schumpeterian business cycle model takes a positive view of the impact of economic crises on firm R&D activities (e.g., Barlevy, 2005; OECD, 2009, 2012; Schumpeter, 1939; Srinivasan et al., 2011). To study the impact of the economic crisis on innovation performance in the global services industry, our article pioneers empirically in the examination of the firm-, industry- and country-level contingent effects on the R&D-performance relationship before and after the crisis.

First, embracing the two conflicting mainstream theories, we consistently find that low-market-share services firms could increasingly derive more value from R&D investments after the 2008 economic crisis. One of the reasons for this observation may be the nature and role of R&D. For example, information and communication technology (ICT) is one of the main investments in the services sector that has contributed to improvements in productivity

[4] Additional information (e.g. result tables of all the robustness tests, and data verification) is available from the authors upon request.

in this industry (Baily & Lawrence, 2001). Over the years, ICT implementation within a company has become simpler and cheaper, improving productivity at lower investment levels, and thus attracting resource-constrained small-medium-sized enterprises (SMEs) to invest in R&D, including innovations in ICT, in order to improve their market share and productivity (Baily & Lawrence, 2001; Jean, Kim & Cavusgil, 2020). This result aligns to some extent with the exogenous shock model but more closely with the Schumpeterian Mark I model for creative use of R&D by small firms in turbulent times. Correspondingly, the last two decades have witnessed a rise in entrepreneurship across the world (Akulava, Marozau, Abrashkevich, & Guerrero, 2020). Our results show that larger firms might have redundant capabilities that lower their efficiencies for quickly recovering from the economic crisis (Teece, Peteraf, & Leih, 2016). In line with the Schumpeterian view, the economic crisis has become an external market correcting mechanism to fix firms' inefficiencies and strengthen firms' productivity-enhancing investments. In so doing, firms with smaller market-share can benefit more in terms of growth rates because of organizational agilities (cf. Luo & Tan, 1998).

Yet there is an alternative explanation for the significantly negative interaction between R&D after the crisis and market share. That is, small firms have higher levels of exit rates in times of crisis than do their larger counterparts, resulting in small but very competitive firms remaining in our post-crisis subsample. Yet our research design provides ways to test alternative explanations: 1) given our sample of listed firms across countries, we exclude firms of very small sizes beforehand, and 2) we conduct a set of robustness checks using firms with more than 250 employees and find that this three-way interaction is still significantly negative. Therefore survival bias among the small firms is not a serious concern in our study.

Second, in the case of the association of financial leverage and services firms' R&D, prior studies have shown that a trade-off exists between financial constraints on R&D search and the monitoring mechanism of discretionary R&D. The monitoring effect may initially dominate the constraint effect due to the experimental nature of innovation. During a crisis, the monitoring mechanism becomes even critical as firms look for investment opportunities to improve their productivity and generate and retain their customers. Moreover, high leverage denotes that these firms are perceived by markets as having some credible means of weathering the crisis and generating valuable equity for their investors, including lenders. These firms have channels for accessing cash during a crisis and focus on R&D, which can potentially generate higher returns after the crisis as well as during it. Our findings provide empirical evidence for this trend with respect to services firm growth, possibly because, as for the high-leveraged services firms, the lenders play an active role in monitoring unnecessary R&D investment during the crisis.

Further, as prior studies show, the growth impact of firms' leverage is closely related to investment opportunity (Billett, King, & Mauer, 2007). That is, leverage does not necessarily reduce growth, but it is negatively related to growth for firms whose investment opportunities are not valuable enough to offset the effect of debt overhang. The crisis provides an interesting scenario for testing the value of R&D investments. When high-leveraged firms increase R&D investments after the crisis, the R&D projects are central to a firm's competitive advantage. We, therefore, observe the positive three-way interaction between R&D after the crisis and debt. Such arguments are also in line with Srinivasan et al. (2011) in marketing and Schumpeter (1939) in innovation research.

Our results also show that it is important to consider the nature of industry dynamism when examining the impact of a crisis on R&D and performance. The results indicate that firms that exist in dynamic industries experience lower returns to R&D compared to those in

stable ones after a crisis. Thus it is crucial to highlight the role of the industry sector in the firm's ability to navigate the external crisis. Firms that are part of stable industries are likely to continue experiencing fewer pressures from customer decline and financial constraints, and thus, they can focus on innovations that address issues emerging from the global crisis. However, firms in industries that are themselves in turmoil and transition will find it difficult to develop innovations that simultaneously address industry dynamism and global crisis. From the exogenous shock model perspective, reduced industry dynamism will impel firms to focus on the external shock introduced by the crisis rather than to manage industry-level changes accompanying turbulence in the business environment. This streamlining of a firm's strategic view will help them adopt R&D investments aligned with the opportunities emergent in the crisis, and thus they benefit from these investments. Schumpeterian Mark II, suggesting that firms in stable industries are better able to derive returns from innovations, provides partial support for this finding.

Last but not least, the role of the national institution system is intriguing. We find that the GFC appears to have a stronger negative impact on the growth of firms when they are located in countries with sound national institutional quality. Yet we also observe that the firms in countries with high institutional quality are better suited to managing a crisis and can generate higher returns from their R&D investments. One way to explain these findings reflect on the importance of national institutional systems for firms. In our sample, countries with high institutional quality are normally advanced ones. Because of strong institutional quality, these countries have mature financial systems, which are, in turn, affected most during the financial crisis. Despite this, these good quality institutional systems (countries) create silos for firms to reduce transaction cost, find a supportive legislative mechanism and protect intellectual property, which remains effective in providing the institutional resources required for innovation (Hall & Soskice, 2001; Hotho, 2014; Whitley, 2007). These findings

are also supported by the exogenous shock model, where it is argued that the support that firms receive during the crisis, as well as the support from the institutional systems, can help these firms emerge well from a crisis period. During the GFC, some countries adjusted their institutional arrangements to sustain their competitive position in innovation, that is, to manage better the uncertain business environment following the global crisis (Fan et al., 2017). Derived from Schumpeterian model, our results indicate a situation in which both the Schumpeterian Mark I and Mark II can be supported, that is, be it entrepreneurial or large, firms can derive returns from R&D investments during a crisis. Under this scenario, national institutional quality provides a conduit for all firms, both entrepreneurial and large, to achieve innovations that target the opportunities in a crisis-dominated business context.

Our study diverges from prior studies of R&D over the business cycle that divides R&D investments into pro-cyclical, anti-cyclical, and non-systematic (e.g., Arvanitis & Woerter, 2013; Filippetti & Archibugi, 2011). Our results, based on listed services firms, reveal some interestingly mixed R&D patterns after the 2008 GFC. As Table 2 shows, in general, R&D intensity significantly decreases after the crisis, which indicates a pro-cyclical trend – increasing in the business upswing and decreasing in the business downturn. However, our regression results in the main analyses and most of the robustness checks find increasing returns to R&D after the crisis and thereby provide anti-cyclical investment patterns – services firms persistent in R&D during negative economic business environments are rewarded, compared to their counterparts.

Moreover, research in this line has identified several mechanisms behind R&D types over business cycles, but it seems subtly incongruent with our study. For example, since opportunity costs are apparently anti-cyclical, it is hypothesized that large firms can benefit more from low opportunity costs through anti-cyclical R&D investment (e.g., Arvanitis & Woerter, 2013). Yet our results show the opposite that there are lower levels of returns to

R&D after the crisis among high-market-share services firms. One possible reason for that is that our research focuses on the services sector, while Arvanitis and Woerter (2013) and others are based on the manufacturing sector. All in all, our exploratory study reveals the coexistence of pro- and anti-cyclical R&D investment behaviors and nuanced mechanisms behind them.

Our study also departs from relevant marketing research on R&D and recessions (e.g., Srinivasan et al., 2011). Besides a different research focus, two methodological issues are noteworthy. First, our research design has a longer time horizon. While we look into returns to R&D five years before and after the 2008 GFC, with year 2008 omitted, Srinivasan et al. (2011) strike a comparison between seven recession years (including the year of 2008) and other non-recessionary years. Second, to calculate returns to R&D, our research design follows Hall et al.'s (2010) Cobb-Douglas production function with two salient features: (1) employing firm growth as a dependent variable and (2) including traditional input of labor and physical capital as controls. Srinivasan et al. (2011) adopt a traditional marketing approach to relate R&D spending to firms' profits. Although differing research designs make sense with regard to theoretical questions and intellectual origins, one needs to be cautious when comparing the consequent empirical results. For example, while we find positive returns to R&D for firm growth in our main analyses, our robustness checks reveal a significantly negative relationship between R&D and firm profits. This casts doubt on firms' profits in the calculation of returns to R&D. Possibly due to different time horizons and idiosyncrasies of services firms, our results also show quite inconsistent moderating effects of market share and financial leverage as compared to Srinivasan et al.'s (2011) work. All of these observations point to a need for further exploration of firm R&D and crisis/recession.

Overall, from the theoretical view, our findings indicate the contingencies that determine the boundaries of the theoretical models and highlight various factors and constraints that

might strengthen the generalizability of results, as well as provide insight into divergent results in studies. We observe that, in the case of the exogenous shock model, the theoretical view needs to incorporate within its boundaries firm-level contingencies such as resources and macro national institutional quality. Similarly, from the Schumpeterian model, we should consider the effects of macro national institutional quality.

In their practical implications, our findings inform both managers and policy-makers. First, the policy focus needs to move from fighting an economic crisis to unleashing technological potential. Although some countries are still trapped by the GFC aftermath, to overlook future technology development may cause even more problems. Second, as shown by our results, SMEs are likely to benefit more from R&D investment, and thus a critical criterion for anticipating entrepreneurial performance is to see how well new ventures identify market opportunities and how governmental and other actors can support these activities. Third, the recent technological revolution has shed new light on management practices. Best practices that were identified previously need to be revisited, including ways of monitoring and industry prescriptions.

Limitations and Future Research Agenda

Our study has several limitations, and these suggest directions for future research. First, Geroski and Walters (1995) suggest that innovation research can be studied from either a 'supply push' or 'demand pull' perspective. Our study arguably belongs to the supply push side of the discussion. However, we agree that market change and customers' demand can affect firms' innovation patterns (e.g., Gourville, 2006). Due to data constraints on exploring more details in the market change mechanisms in this study, we encourage future studies to explore more the market change before and after the crisis and how such a change affects firms' innovation investments and performance. Second, our empirical design aims to address the five questions presented in the theory section, and it is plausible that there are other

potential moderators. Third, the time frame of our data limits our focus to the recent GFC. Future research that compares the patterns of different crises, based on a longer time frame of data, can broaden our vision of crisis and R&D. Fourth, the study focuses on normalized R&D expenditure as a proxy of research intensity and ignores different types of innovation toward firms, such as exploitative *versus* explorative or sustaining *versus* disruptive innovation. Since different types of innovation can generate varying risk profiles, returns to each type of innovation are likely to vary. We suggest future research can take one further step to test whether returns to different types of innovations can be different before and after the crisis. Fifth, our sampling of traditional services firms (e.g., airlines, hotels) may limit the scope of our research. Today, some of the most valuable firms in the world offer services on digital platforms to customers globally. Future work should consider R&D returns of such firms specifically, and address how and why it may differ from more traditional services. Finally, given the huge variance between developed and developing countries, future research can also propose a better country taxonomy for examining returns to R&D across countries.

CONCLUSION

Utilizing a large panel dataset of 11,635 company-years from 82 countries for the period 2003-2013, we observe that returns to R&D among services firms consistently and significantly increase after the crisis, and that firm-, industry- and country-level differences exist in performance effects of R&D before and after the crisis. We further show that the change in the performance effect of R&D after the crisis is contingent on firm-specific idiosyncrasies, industry dynamism, and national institutional quality. Given contingencies explored, our results find support in both the exogenous shock and Schumpeterian models to a certain extent, thus calling for in-depth analyses and theoretical development in future studies.

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TABLE 1
Descriptive Statistics of the Dataset by Country

Region	No. observations	No. firms	No. large firms	Sample services firm percentage	Mean R&D intensity	S.D. R&D intensity	Mean employees	Missing year
JAPAN	2,332	785	557	0.758	0.035	0.212	5236	None
UNITED STATES	2,211	454	200	0.108	0.380	0.669	4707	None
UNITED KINGDOM	1,193	374	165	0.473	0.111	0.340	10796	None
GERMANY	739	211	94	0.644	0.072	0.265	11639	None
FRANCE	726	211	122	0.629	0.098	0.365	19441	None
CHINA	694	359	187	0.399	0.060	0.214	4645	None
CAYMAN ISLAND	322	158	104	0.413	0.076	0.137	2675	None
ISRAEL	279	145	44	0.564	0.158	0.422	702	None
SWEDEN	234	85	37	0.557	0.102	0.378	5221	None
AUSTRALIA	231	109	32	0.251	0.393	0.814	1851	None
MALAYSIA	191	113	73	0.470	0.001	0.005	2416	2010,2011,2012
INDONESIA	152	82	53	0.571	0.000	0.000	2543	2005,2006,2010,2012
BERMUDA	149	102	58	0.463	0.040	0.233	1864	None
SINGAPORE	146	83	53	0.512	0.005	0.015	2082	2006
THAILAND	145	83	49	0.533	0.024	0.230	995	2004,2005,2006,2009,2010,2011,2012
SPAIN	131	44	26	0.584	0.010	0.023	24227	None
NETHERLANDS	126	43	30	0.628	0.038	0.242	14586	None
SWITZERLAND	119	33	22	0.473	0.057	0.172	10351	None
FINLAND	116	22	13	0.698	0.248	0.636	4182	None
ITALY	115	46	30	0.491	0.011	0.033	5860	2004
KOREA	108	32	11	0.082	0.068	0.148	881	None

Notes. [a] The large firms are those with the numbers of employees more than 250 persons.
[b] We calculate the sample firm percentage by dividing the number of sample firms by the number of listed services firms in the BvD Osiris database for the period of 2003 to 2013 each country.
[c] R&D intensity is winsorized at the top 2% of the sample.

TABLE 2
Summary Statistics: Key Variables before and after the Crisis

Table 2 shows R&D intensity and growth before and after the crisis for the subgroups of firms. The sample consists of 11,635 firm year observations from 2003 to 2013. High (/low) values includes all firms in the top (/last) quintile each year.

Panel A: R&D intensity before and after the crisis

	1. Before the crisis	2. After the crisis	Difference (2-1)	p-value for t-test
Whole sample	0.1410	0.1270	-0.0140	0.0761
a. Low market share	0.2222	0.2007	-0.0215	0.1302
b. High market share	0.0647	0.0496	-0.0152	0.0159
Difference (b-a)	-0.1575	-0.1512		
p-value for t-test	0.0000	0.0000		
a. Low debt	0.1977	0.1605	-0.0371	0.0038
b. High debt	0.0882	0.0916	0.0034	0.7071
Difference (b-a)	-0.1095	-0.0690		
p-value for t-test	0.0000	0.0000		
a. Low industry dynamism	0.1663	0.1680	0.0017	0.8879
b. High industry dynamism	0.1150	0.0869	-0.0281	0.0048
Difference (b-a)	-0.0513	-0.0810		
p-value for t-test	0.0000	0.0000		
a. Low institutional quality	0.1365	0.1278	-0.0087	0.4273
b. High institutional quality	0.1475	0.1264	-0.0211	0.0715
Difference (b-a)	0.0110	-0.0014		
p-value for t-test	0.3860	0.8863		

Panel B: Firm growth before and after the crisis

	1. Before the crisis	2. After the crisis	Difference (2-1)	p-value for t-test
Whole sample	0.1325	0.0353	-0.0972	0.0000
a. Low market share	0.1554	0.0636	-0.0918	0.0000
b. High market share	0.1109	0.0056	-0.1054	0.0000
Difference (b-a)	-0.0445	-0.0580		
p-value for t-test	0.0030	0.0000		
a. Low debt	0.1508	0.0461	-0.1047	0.0000
b. High debt	0.1154	0.0239	-0.0915	0.0000
Difference (b-a)	-0.0355	-0.0223		
p-value for t-test	0.0178	0.1001		
a. Low industry dynamism	0.1326	0.0516	-0.0810	0.0000
b. High industry dynamism	0.1323	0.0194	-0.1130	0.0000
Difference (b-a)	-0.0002	-0.0322		
p-value for t-test	0.9868	0.0173		
a. Low institutional quality	0.1223	0.0676	-0.0547	0.0002
b. High institutional quality	0.1470	0.0107	-0.1364	0.0000
Difference (b-a)	0.0248	-0.0569		
p-value for t-test	0.1034	0.0000		

TABLE 3
Means and Correlation Coefficients

Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7	8	9
1. Growth $_{t}$	0.078	0.544	-7.073	8.448									
2. R&D intensity $_{t-1}$	0.133	0.423	0.000	2.687	0.079								
3. ΔPhysical assets $_{t-1}$	0.043	0.617	-7.869	7.418	0.080	-0.041							
4. ΔEmployees $_{t-1}$	0.050	0.387	-6.725	7.303	0.114	-0.041	0.343						
5. Firm age $_{t-1}$	26.010	26.570	0.000	221.000	-0.039	-0.151	-0.013	-0.022					
6. Market share $_{t-1}$	0.813	2.742	0.000	66.080	-0.022	-0.078	0.008	0.001	0.206				
7. Debt $_{t-1}$	0.510	0.240	0.120	0.958	-0.030	-0.103	-0.049	-0.042	0.175	0.198			
8. Industry dynamism $_{t-1}$	1.081	0.755	1.000	77.870	0.017	0.001	0.011	-0.007	-0.009	-0.007	-0.0171		
9. Institutional quality $_{t-1}$	1.042	0.572	-1.900	2.042	-0.006	0.085	-0.007	0.007	0.066	0.087	0.0139	-0.010	
10. Post-crisis $_{t-1}$	0.560	0.496	0.000	1.000	-0.089	-0.016	0.000	0.039	0.034	-0.049	-0.031	-0.019	-0.0123

Notes.[a] All correlations with absolute value greater than or equal to 0.008 are significant at 5% level or less.

[b] ΔPhysical assets and Δemployees are log-transformed. The mean and S.D. of physical assets are 1625729 dollars and 8735283. The mean and S.D. of employee are 7097 and 31474.52.

[c] Firm age is the number of years since its founding. Although the founding year, by the BvD's definition, indicates the year when the company has been registered for the first time, firms adopt different standards – some may define the first order for goods, the listing year, restructuring or others as a beginning. To remedy this problem, we conduct two sets of robustness checks by (1) keeping the observations whose age is larger than three years, and (2) excluding firm age as a control variable, finding that the signs and significant levels are paralleled to those in our main analyses.

[d] Because the market shares of some companies are negligible compared to the global industry sales, they are rounded to 0 in the descriptive analyses.

[e] N = 11,635.

TABLE 4
R&D and Firm Performance after the Crisis - Production Function - FE

	Controls	**R&D and crisis**	**Moderator = Market Share**		**Moderator = Debt**		**Moderator = Dynamism**		**Moderator = Institutional quality**		**Full Model**	
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
R&D intensity	0.540***	0.485***	-0.372	-0.464**	0.443***	0.405***	0.485***	0.332*	0.751**	0.783**	-0.120	-0.327
	(0.073)	(0.072)	(0.277)	(0.206)	(0.083)	(0.085)	(0.184)	(0.201)	(0.301)	(0.307)	(0.419)	(0.387)
ΔPhysical assets	0.042*	0.041	0.041	0.041*	0.041	0.040	0.041	0.043*	0.042*	0.041	0.041	0.042*
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
ΔEmployees	0.119***	0.121***	0.122***	0.121***	0.121***	0.119***	0.121***	0.119***	0.121***	0.122***	0.121***	0.118***
	(0.034)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.034)	(0.033)	(0.033)
Firm age	-0.021	-0.020	-0.020	-0.020	-0.020	-0.020	-0.020	-0.023	-0.016	-0.017	-0.015	-0.021
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Market share	-0.028***	-0.029***	-0.068***	-0.073***	-0.029***	-0.029***	-0.029***	-0.029***	-0.030***	-0.030***	-0.069***	-0.073***
	(0.007)	(0.007)	(0.014)	(0.012)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.015)	(0.014)
Debt	0.050	0.027	0.017	0.021	0.045	0.064	0.027	0.018	0.028	0.033	0.030	0.057
	(0.076)	(0.075)	(0.075)	(0.075)	(0.077)	(0.076)	(0.075)	(0.076)	(0.075)	(0.074)	(0.077)	(0.076)
Industry dynamism	0.010	0.010	0.010	0.010	0.009	0.010	0.010	0.022	0.009	0.009	0.008	0.029*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.016)	(0.018)	(0.008)	(0.007)	(0.015)	(0.016)
Institutional quality	0.158**	0.151*	0.152*	0.157**	0.152*	0.150*	0.150*	0.139*	0.118	0.115	0.120	0.105
	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.074)	(0.074)	(0.074)	(0.073)
Post-crisis	0.056	0.039	0.019	-0.039	0.042	0.041	0.062	-0.002	0.139	0.133	0.192	0.073
	(0.178)	(0.172)	(0.173)	(0.170)	(0.173)	(0.173)	(0.200)	(0.193)	(0.176)	(0.176)	(0.201)	(0.194)
R&D × post-crisis		**0.183****	0.160**	-0.528**	0.202**	0.268***	0.183**	0.908**	0.199**	-0.307	0.201**	-0.399
		(0.079)	(0.079)	(0.217)	(0.080)	(0.080)	(0.079)	(0.363)	(0.079)	(0.483)	(0.079)	(0.492)
Post-crisis × market share			-0.011***	-0.042***							-0.012***	-0.047***
			(0.004)	(0.011)							(0.004)	(0.011)
R&D × market share			-0.438***	-0.479***							-0.440***	-0.467***
			(0.136)	(0.100)							(0.147)	(0.124)
R&D × post-crisis × market share				**-0.354*****								**-0.435*****
				(0.122)								**(0.120)**

TABLE 4 (continued)

	Controls	**R&D and crisis**	**Moderator = Market Share**		**Moderator = Debt**		**Moderator = Dynamism**		**Moderator = Institutional quality**		**Full Model**	
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Post-crisis × debt					0.062	0.005					0.091	0.033
					(0.068)	(0.060)					(0.070)	(0.061)
R&D × debt					-0.202	-0.418*					-0.238	-0.485**
					(0.180)	(0.240)					(0.179)	(0.243)
R&D × post-crisis × debt						**0.414***						**0.424***
						(0.242)						**(0.249)**
Post-crisis × industry dynamism							-0.023	0.061			-0.070	-0.018
							(0.127)	(0.102)			(0.126)	(0.100)
R&D × industry dynamism							0.000	0.133			-0.003	0.222
							(0.161)	(0.181)			(0.159)	(0.156)
R&D × post-crisis × industry dynamism								**-0.651****				**-0.926*****
								(0.326)				**(0.332)**
Post-crisis × Institutional quality									-0.124***	-0.106***	-0.123***	-0.081**
									(0.029)	(0.038)	(0.028)	(0.037)
R&D × institutional quality									-0.219	-0.243	-0.250	-0.379
									(0.231)	(0.238)	(0.235)	(0.231)
R&D × post-crisis × institutional quality										**0.391**		**0.666***
										(0.372)		**(0.370)**
Firm-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,635	11,635	11,635	11,635	11,635	11,635	11,635	11,635	11,635	11,635	11,635	11,635
Within R^2	0.082	0.088	0.091	0.092	0.089	0.092	0.088	0.091	0.091	0.093	0.097	0.110
F	16.72	18.55	18.05	18.61	17.26	17.10	17.60	17.45	18.24	17.56	15.80	15.37

Notes: Robust standard error in the parenthesis. * p < 0.1, ** p <0 .05, *** p <0.01.