Effects of R&D Investment on Profitability and Firm Value of Young Firms

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Abstract

We examine the effects of R&D activities of young firms on their performance. Using publicly traded non-financial firms between 2001 and 2015, our study finds that young firms do not necessarily invest more in R&D activities than old firms. Young innovative firms face distress and difficulty in external funding during a macro-economic crisis more than old firms. After the crisis, the effects of R&D investment on firm value in the stock market are smaller in young firms than old firms, suggesting investors lower the value of growth option for young innovative firms. In contrast to a conventional belief, our findings suggest the weaker role of young firms in innovative activities.

Key words: R&D investment, Young firms, innovation, profitability, stock market value

JEL code: G01, G3

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1. Introduction

Economists often argued that innovation is a key contributing factor to economic growth (Nelson, 1959; Arrow, 1962; Griliches, 1979; Solow, 1957; Fagerberg, 1994). In particular, new entrants would make major dramatic innovations while incumbents are making incremental changes (Abernathy and Clark, 1985; Tushman and Anderson, 1986; Henderson and Clark, 1990; Criscuolo et al., 2012; Akcigit and Kerr, 2010; Klette and Kortum, 2004; Acemoglu and Cao, 2010). "Disruptive" innovations of new entrants can make old incumbents' existing knowledge vulnerable to attacks from new entrants (Bergek et al., 2013).

Consistent with such conventional belief, stock market investors seem to believe that young firms are innovative and they represent the engine for growth. Investors in the stock market react positively to larger R&D spending especially in small or young firms. For instance, Lee and Chen (2009) argue that investors evaluate more optimistically smaller firms that are likely to be more innovative and entrepreneurial. Given that stock market valuation includes value of growth options (Chan et al., 2001), young innovative firms tend to have higher market value, even though young firms often show low profitability.

However, such belief that young firms engage in innovate activities more than old firms faces some challenges in recent years. Firstly, young firms do not necessarily invest more in R&D activities. Investment activities of young firms are volatile and more sensitive to available funding such as cash flows than those of old firms (Alti, 2003). Note that as young innovative firms often have low profitability, their internal financing is not enough and R&D volatility is greater except in firms with large cash holdings (Brown and Petersen, 2011). During and after the 2008 crisis, in the midst of aggravated volatility and funding difficulties, many young innovative firms reduce their R&D investment. Furthermore, such reduction is greater when they face financial distress (Paunov, 2012) or when firms face difficulties in external funding (Giebel and Kraft, 2015).

Secondly, past studies argue that young firms have lower productivity and less effective in innovation activities than incumbents or old competitors, as reviewed in Van Praag and Versloot (2007) and Nightingale and Coad (2013). Using patent citations of 387 U.S. semiconductor and biotechnology firms, Sorensen and Stuart (2000) find that time between patent citations increases with size and age. In fact, young firms can face difficulty in turning knowledge into innovative activities. Supporting the moderating effect of organization age on the relationship between learning orientation and firm innovativeness, Calantone et al. (2002) explain that older firms are more likely to employ knowledge learned and turn it into innovation activities than younger competitors. Incumbents which are generally old firms show a higher productivity growth which plays a major role in industry productivity growth than young counterparts (Bartelsman and Doms, 2000; Foster et al. 2002). In general, past research argues that innovation-performance relationship is context dependent and firm age affects the impact of innovation on firm performance to a large extent (Rosenbusch et al., 2011). In addition, as most R&D expenditures entail suck costs (Stiglitz, 1987), old firms with history of R&D activities tend to persistently invest in R&Ds (Manez et al., 2009), resulting in persistence in firms' R&D behavior.

In short, previous studies suggest that young innovative firms face difficulties in external funding to finance their R&D activities, and may not reach an optimal level of investment or do not complete their R&D activities. Moreover, even with innovative knowledge, young firms do not necessarily turn it into a successful business. Considering the hindrance, the value of growth options can be smaller.

Reflecting recent challenges in R&D activities in young firms, we investigate R&D activities of young firms and their impact on profitability and firm value. To our knowledge, our paper is the first study that examines how R&D activities of young firms affect accounting and stock market performance such as profitability and firm value based on publicly listed firms in the US. Using Spanish manufacturing firm data, Coad et al. (2013) examined the impact of R&D of young firms on firm activities such as sales, productivity, or employment. Their sample only covers around 51% of total population firms in manufacturing sectors. However, they do not examine the impact on corporate profitability or market values. As profitability or stock market values are directly related to firm's long term survival and growth (more than employment or sales growth), our performance variables are more suitable to examine the relationship between innovation and economic growth.

This study focuses on three questions. Firstly, we examine whether young firms invest more in innovative activities such as R&D, capital expenditure or total investment, using multivariate analysis. In other words, do young firms invest more in growth options? Do young firms face a larger reduction in R&D activities after a crisis? Secondly, do young innovative firms face a higher probability of financial distress or exits during a crisis or after a crisis? When young innovative firms are able to generate profits (or cash flow is large, or cash holding is large) do they face a reduction in the probability of distress, and even face an exit threat? Thirdly, we examine the effects of R&D activities and CAPEX on firm profitability and market value. We test whether the valuation effects have changed after the 2008 crisis.

Using all publicly listed, non-financial firms in the US stock markets between 2001 and 2015, we have found that young firms do not necessarily invest more in R&D activities; controlling a firm's financial constraint, old firms significantly spend more on R&D, acquisition, capital expenditure and total investment. Moreover, effects of R&D on profitability are larger in old firms and the effects gets stronger after the 2008 crisis. At the given level of R&D, the result strongly supports our argument that old innovative firms show higher profitability than young counterparts after the 2008 crisis, while young innovative firms only show higher profitability in the pre-crisis period. The effects of R&D on Tobin's Q are larger in young firms throughout the period we investigate, but at the given level of R&D, old "innovative" firms hold higher market value than young innovative ones. Finally, young firms are more likely to exit from the market when their R&D spending is larger. During crisis, young firms are more likely to suffer from financial distress when their R&D spending is larger.

Our results are robust in that our main arguments hold across different methods of classifying young versus old firms. Specifically, our results remain the same when we classify the sample as young firms when they are less than 8 years old, until 10 years after IPO, or when they belong to the lower half of median age in the sample following Duchin et al. (2010). Two, our main results also hold in industries with high R&D activities such as computers and office machinery, aerospace and defense, pharmaceuticals, and electronics and communications. Even in such innovative industries identified in other studies (Cloodt et al., 2006), our study finds the weakness of young firms in terms of their profitability and market value effects of R&D investment.

This paper contributes to empirical studies on R&D and firm value in economics and finance.

Also, we add some findings to empirical literature on innovation, given that empirical studies on innovation and corporate life-cycle using financial data are scarce. While theoretical literature distinguishes new entrants from incumbents in innovation (Jovanovic, 1982; Ericson and Pakes, 1995), empirical studies are scarce on innovation over the life course of firms using Spanish data (Coad et al., 2013).

Our findings suggest that the theoretical literature on R&D innovation can consider higher probability of failures for young firms or new entrants. Even when young firms have more dramatic innovative ideas, innovation activities in these young firms can fail with a higher probability than old firms. In addition, our study can provide a clue why recent IPO activities are weaker than before. As young innovative firms often show lower profitability and are more likely to suffer during the 2008 crisis, investors seem to less appreciate the growth option value of young firms after the crisis. Lower valuation for young innovative firms might explain why recent IPO activities are weaker than before.

Nevertheless, it is still too early to argue that a smaller role of young or small firms. While our study shows the weaker role of young firms in innovative activities after the 2008 crisis, our study is based on relatively short time period covering 2001 to 2015. Our results might stem from the paucity of dramatic innovation and technological changes during our sample periods. If we examine a longer time period, or time period of dramatic innovation and technological changes, our results can be different. Therefore, future studies should consider performance of the young and small firms when there is a large technological change.

Our paper is organized as follows. Section 2 discusses prior research on the corporate cash holdings. Section 3 develops hypotheses. Section 4 describes our data and empirical strategy. Section 5 presents our empirical results. Section 6 discusses implications. Section 7 concludes.

2. **Literature review and background**

The economic literature has developed various theoretical models which describe Schumpeterian process. One class of those models focuses on the learning process: On the one hand, in the passive learning model (Jovanovic, 1982) young firms should have higher and more variable growth rates. On the other hand, in the active learning model (Ericson and Pakes, 1995), a firm actively explores its economic environment and invests to enhance its profitability. In both models, each entrant starts with a different initial condition reflecting differences in their own perceived ability.

It can be difficult to realize growth option for young firms, since the learning process is crucial for innovation activity and the subsequent firm performance. As in Calantone et al. (2002), old firms are more likely to employ knowledge learned and turn it into innovation activities. Young firms, however, need to establish an efficient mechanism for rapidly internalizing knowledge. In this sense, the impact of R&D may be different depending on the firm life course: young firms must make a larger R&D effort in order to survive, and internal R&D investment may be crucial for their performance. Successful innovation by young firms could lead to sustainable competitiveness, whereas unsuccessful innovation may mean early failure and bankruptcy.

With respect to a firm's early years, empirical investigations into industrial dynamics have found two main results. First, entrants find the value of new ideas (Audretsch, 1995) which leads to a disruptive effect on the market by introducing new innovations. However, entrants often face circumstances of high uncertainty and do not have an established revenue base, so they might be better able to refocus their sale on new innovative products and services. Second, young firms might over-estimate their capacity to innovate and so their attempts at innovation might not be successful. Therefore, they are not able to introduce their ideas in order to survive in the market.

The innovation process requires sizeable investments in R&D projects and taking substantial risks. Only firms with sufficient accumulated profits and with less financial constraints can survive when one innovative project fails. Empirical evidence shows that old firms, on average, tend to be bigger and possess a larger accumulated stock of profits (Coad et al., 2013). Hence, old firms may be more prepared to overcome innovation failures. In this sense, Young firms are less efficient in R&D. Brown and Petersen (2011) find that young firms consume cash holdings to dampen the volatility in R&D by approximately 75% during the 1998–2002 boom and bust in equity issues.

The empirical literature has found both negative and positive effects of firm age on innovation. Evidence on the positive impact of firm age on the innovative process states that young firms often face difficulties associated with lack of market recognition and economies of scale and lack of alliances with partners. As firms grow older, they are able to strengthen their available resources, managerial knowledge and the ability to handle uncertainty (Herriott et al., 1984; Levitt and March, 1988). Also old firms have much more reputation and market position which facilitate relationships and contacts. There is evidence on the positive effect of firm age on the likelihood of superior organizational structure (Argote, 1999), new product development (Hansen, 1999; Sivadas and Dwyer, 2000) and innovative outcomes (Tripsas and Gavetti, 2000). Recent paper by Coad et al. (2013) analyze Spanish firms found that R&D of young firms is riskier, whereas the benefits from R&D of old firms are more constant.

However, some empirical evidence show that firm age is negatively related to innovation. For instance, Majumdar (1997) noted that older firms are liable to experience some form of inertia, which may prevent them from the learning effect. Sorensen and Stuart (2000) identify two effects of age on innovation, which are learning effects and obsolescence effects. Relatedly, Balasubramanian and Lee (2008) analyze data on patents of Compustat firms and found that firm age is negatively related to technical quality, and that this effect is greater in technological industries.

Other studies also assess how firm performance relates to the performance of their competitors. As in Taymaz (2005), young firms become aware of their actual productivity after observing their competitors' performance in the industry. In fact, this is consistent with the finding that young firms generally enter with productivity levels lower than that of incumbents (Jensen et al., 2001; Huergo and Jaumandreu, 2004a, 2004b; Coad et al., 2013).

3. **Hypothesis**

Reflecting recent challenges in R&D activities in young firms, we investigate R&D activities of young firms and their impact on performance.

First, building on previous studies, we examine whether firm age affects corporate investment in innovative activities. As we discussed earlier, in contrast to conventional belief, we argue that young firms do not necessarily invest more in innovative activities. In particular, we hypothesize that after experiencing a crisis, young firms invest less in R&D activities.

H1: Young firms invest less in R&D activities after a crisis.

Secondly, we examine why young firm invest less in R&D activities or growth options in general after the 2008 crisis. Among many difficulties that young firms face, we focus on financial difficulties after the market experiences a crisis. We test whether young innovative firm face a higher probability of financial distress during the 2008 crisis, or a higher probability of exit during 2001-2015. This leads to our second hypothesis:

H2: Young innovative firms face a higher probability of financial distress or exits during a crisis or after a crisis.

Finally, we examine the effects of young firms' investment on corporate profitability and market value. As studies suggest young firms do not have organization learning and are less efficient in innovation, we postulate that the effects of R&D investment of young firms on firm profitability and market value is smaller than those of old firms. This leads to our third hypothesis.

H3: The effects of R&D activities of young firms on firm profitability and market value are smaller after the 2008 crisis.

4. DATA and Methodology

Our sample consists of quarterly data on publicly traded, non-financial U.S. firms available on Compustat database from 2001 to 2015. Using the quarterly compustat data, Shin and Kim (2002) find that corporate investment is significantly higher in the fourth quarter than other periods. As firms financing or investing activities vary over fiscal quarters, using quarterly data can provide more accurate information firms' investment decisions including R&D spending and market value. Additionally, quarterly data reflect different market valuation from what is valued at the beginning and at the end of the period. Using quarterly data provide us with a timelier source of information useful to examine corporate innovation, represented by R&D investment on firm performance as well as market value.

We exclude financial firms and utilities with SIC codes of 4900-4949 and 6000-6969. Following Gulen and Ion (2016), all observations have total assets. We exclude firms with sales or book equity smaller or equal to zero. For firms that change their fiscal year convention, we keep the most recent fiscal year convention. This leaves us final sample of 288,322 out of 306,433 firm-quarter observations.

As for dividing young and old firms, the classification method varies across studies. Depending on the industry setting, it can take between 8 and 12 years until companies mature (Covin et al., 1990; Zahra, 1996). We use an average age of 12 years as a cut-off point between young and mature firms, following Rosenbusch et al. (2011). In addition, following Duchin et al (2009), we classify firms as old and young by dividing the sample at the median each quarter using firm age as robustness tests. Moreover, our results remain the same when we classify the sample as young firms when they are less than 8 years old, and firms until 5 years after IPO.

For R&D, we divide R&D expense (xrdq) by total assets (atq); acquisition is obtained by dividing acquisition (acq) by total assets (atq); investment is the ratio of quarterly capital expenditure to total assets using quarterly data from 2001 and 2015 in Compustat data, following Duchin et al. (2010). Since capital expenditure is reported on a year-to-date basis in quarterly financial statements, we subtract the previous quarter's capital expenditure from the current quarter's capital expenditure (capxy) for fiscal quarters 2, 3, and 4 (Duchin et al., 2010). As in table 1, R&D and acquisition have smaller sample size due to missing variables, so based on Bates et al. (2009), we replace missing variables with zero for the two variables. We winsorize all independent variables at the 1st and 99th percentiles to reduce the influence of outliers. We detail the construction of the variables in the Appendix.

We define the beginning of the financial crisis as the third quarter of 2007 (2007Q3), as in Duchin et al. (2010) and Kahle and Stulz (2013), ending in the second quarter of 2009 (2009Q2). We begin our main sample in the third quarter of 2001 (2001Q3) in order to equally divide the main sample period into pre- and post-crisis periods. Thus the pre-crisis period is defined as 2001Q3 to the second quarter of 2007 (2007Q2), and the post-crisis period is from the third quarter of 2009 (2009Q3) to the second quarter of 2015 (2015Q2) when the interest rates are low.

Figure 1 shows the time trend of different types of corporate investment activities in young firms and old firms. We calculate the weighted-average investment, represented by the ratio of capital expenditure to total asset, R&D to total assets, acquisition to total assets, total investment to total assets and sales growth. Young firm generally exhibits lower investment than old firms. Specifically, capital expenditure or investment of young firms is higher than young firms; acquisition of old firm is higher than young firms; R&D, however, exhibits different pattern from other types of investment, but young firm's R&D spending follows downward trend during 2000s; total investment is the sum of capital expenditure, acquisition and R&D minus sale of property, plant and equipment, and old firm holds higher amount than young counterparts. We use total investment following Richardson (2006). Sales growth of old firm gets higher after 2003 than that of young firms.,

[Figure 1]

4.1. Methodology

We try to test how corporate age of innovative firms affects firm performance in three steps. First, we examine whether young firms invest more in innovative activities and whether such relationship has changed after the 2008 crisis. Second, we test whether young innovative firms face a higher probability in financial distress and exits. Third, we examine the effects of young innovative firms on corporate accounting performance and stock market value.

First, we examine the effects of corporate age on investment using equations similar to those commonly employed for testing the Q theory of investment (Erickson and Whited, 2006; Bloom et al., 2007; Gulen and Ion, 2016; Denis and Sibilikov, 2010). We include firm age, the number of years since the firm's initial appearance in Compustat/CRSP database with non-missing financial information into the equation as follows:

$$Investment_{i,t} = \beta_0 + \beta_1 Age_i + \beta_2 Age_i \cdot CF_{i,t-1} + \beta_3 Age_i \cdot CF_{i,t-1} \cdot Post + \beta_4 X_{i,t} + \beta_5 Post \cdot X_{i,t} + \beta_7 M_{i,t-1} + \mu_i + \tau_t + \varepsilon_{i,t} \quad (1)$$

,where $Investment_{i,t}$ is measured as capital expenditure scaled by lagged total assets; $X_{i,t}$ is a vector of firm-level variables which include Cash, Tobin's Q, Cash Flow and sales growth (SG), property, plant and equipment (PPEA), sale of property, plant and equipment (PPE), leverage, R&D, size, equity issuance and debt issuance following Denis and Sibilikov (2010). SG is measured as the year-on-year percentage change in sales. We also include the interaction terms of $X_{i,t}$ with Pre and Post dummies. Due to the previous literature that young firm find it difficult to invest when they face financial constraint, we interacted age with cash flow. To control for overall macroeconomic conditions, we use lagged quarterly change in GDP for $M_{i,t-1}$. As before, μ_i is firm fixed effect, and τ_t represents a set of fiscal and calendar-quarter dummies. We employ differences-in-differences (DID) approach in which we compare the cash effects on firm investment before and after the 2008 crisis as a function of observable measures of investment opportunities and other firm-level variables, controlling for firm fixed effects. While doing DID analysis, we use pre-crisis (2001Q3 to 2007Q2), and the post-crisis period (2009Q3 to 2015Q2) without using the crisis period (2007Q3 to 2009Q2).

In equation (1), the coefficients for $\beta_1$measures the effect of firm age on investment. If β_1 is significantly positive, it supports our first hypothesis that young firms invest less than old firms. Moreover, interaction terms, β_2 and β_3 measure the additional effect of firm age, given the level of cash flow, on investment and that of post-crisis period, respectively. Thus, if β_2 or β_3 are significantly different from zero, the firm age variable has a significantly different effect on investment and that in the post-crisis periods.

To quantify a firm's innovativeness, we use R&D spending (Koga, 2005; Castany et al., 2005; Yang and Huang, 2005). $R\&D_t$, which is the research and development expenses at time t, divided by total assets at time t, is used for dependent variable of equation (1). For robustness of innovative spending and other types of firm investment, we also use capital expenditure at time t, $CAPEX_t$; acquisition at time t, $Acquisitons_t$, and total investment, $I_{TOTAL,t}$. Total investment is sum of four different investment activities.

$$I_{TOTAL,t} = CAPEX_t + Acquisitions_t + R\&D_t - SalePPE_t \quad (2)$$

,where $I_{TOTAL,t}$ refers to the total investment; $CAPEX_t$ is capital expenditure at time t; $Acquisitons_t$ is acquisitions; $SalePPE_t$ is the sale of property, plant and equipment (Richardson, 2006).

Second, we test whether young innovative firms face a higher probability in financial distress and exits. Following Fernandes and Paunov (2015), we use probit regressions to estimate the effect of R&D innovation on firm survival:

$$Exit_{i,t} = \beta_1 Age + \beta_2 R\&D + \beta_3 Age \cdot R\&D + \beta_4 R\&D \cdot crisis + \beta_5 R\&D \cdot crisis \cdot age + \beta_6 R\&D \cdot post + \beta_7 R\&D \cdot post \cdot age + \delta_1 \cdot controls_{i,t-1} + \alpha_t + \gamma_i + \varepsilon_{i,t} \quad (3)$$

The specification has a binary dependent variable equal to 1 in the quarter of exit for firms and 0 otherwise. Control variables include sales growth, capital intensity, firm size, firm size squared, firm initial size, firm initial size squared, industry sales growth, industry herfindahl index and industry herfindahl index squared. While Fernandes and Paunov (2015) use plant and product data in Chile, we use financial data in U.S., so we do not have access to plant and product innovation measure they did. Instead, we change the plant to firm variable, and add R&D spending.

Third, we examine the effects of young innovative firms on corporate accounting performance and stock market value. Based on Aktas and Petmezas (2015), we study the impact of firm age and its efforts on innovation, represented by R&D spending, on firm performance using the following linear regression specification:

$$V_{i,t} = \beta_1 Age + \beta_2 R\&D + \beta_3 Age \cdot R\&D + \beta_4 R\&D \cdot post + \beta_5 R\&D \cdot post \cdot age + \delta_1 \cdot controls_{i,t-1} + \alpha_t + \gamma_i + \varepsilon_{i,t} \quad (4)$$

,where controls include firm size, intangible assets, leverage, risk, fixed assets growth, cash, sales volatility, cash flow, financial distress dummy and sales growth. Following Aktas et al. (2010), we also add firm spending such as capital expenditure, acquisition and R&D, and also interacted those variables with crisis period dummy to see if firm spending or investment results in different performance after the 2008 crisis. For dependent variable, we use Tobin's Q and return-on-asset (ROA henceforth) to estimate the firm's market value and operating performance affected by firm innovation, respectively.

Table 1 provides summary statistics for our sample during 2001Q3 – 2015Q2. The average investment ratio, R&D and acquisition for the entire sample period is 0.015, 0.018 and 0.005, respectively. The median investment, R&D, and acquisition ratio are 0.007 and zero. Last four columns show the subgroup means and whether each subgroup mean are statistically different from each other when firms are grouped based on firm size and age. The mean of young firm variables are significantly different from old counterpart, and the same result goes for the mean of big and small firms.

5. Findings and robustness tests

Table 2 summarizes the results that young firms do not invest more than old firms over the whole sample period. In fact, it turns out that old firm spends significantly more on R&D, acquisition and total investment than young counterparts. We find that given the level of cash flow, old firm spends more than young firms on capital expenditure, acquisition and total investment. Given that cash flow can be thought as measures of a firm's financial constraint, it indicates that young firms do not spend as much as old competitors do on capital expenditure, acquisition and total investment out of their financial constraint, following previous studies.

However, this result gets weaker when we go through financial crisis, as indicated in cash flow interacted with age and post-crisis dummy. Looking at the coefficient for age interacted with post-crisis dummy, all coefficients get insignificant, compared with significantly positive age coefficient for R&D, acquisition, and total investment. It implies that firm age in the post-crisis does not affect firm investment. When we interact firm age with cash flow measure, coefficient for the post-crisis implies that old firm, under the given level of cash flow, invest significantly more than young firm in investment and total investment, but the magnitude gets smaller. In sum, old firms invest significantly more than young firm, especially if a firm holds certain amount of cash flow, but it gets weaker after the 2008 crisis.

[Table 2]

In table 3, the dependent variable is financially distress dummy, and it describes the results for financial distress for firms in the 2008 crisis period. It turns out that young firm falls into financial distress easier than old counterparts. While R&D is not significant, the coefficient of the interaction term between R&D and Age is negative and significant. These results indicate that a firm that puts effort on R&D in the crisis period does not face a higher possibility of financial distress. However, the negative coefficient of R&D interacted with age shows that at the given level of R&D, young firm faces higher possibility of financial distress.

[Table 3]

Table 4 summarizes the results on whether innovation, represented by R&D in this paper, expose firms to survival risks and whether such relation varies over firm age. Young firms face significantly higher threat of exit, and old firms which put more effort on R&D does not necessarily face exit threat. However, R&D effect on firm exit is positive when it is in crisis period, and less significantly positive in the post-crisis period, meaning that R&D effort may expose firms to survival risks in those periods. Moreover, interacted term of R&D and age shows that at the given level of R&D, old firm face more possibilities of exit, and this result gets weaker when it is in crisis and post-crisis period. Some may argue that the given the result from the coefficient of R&D interacted with age can be counterevidence of our result, but we postulate that the market exit can include such events as exit out of M&A, which requires additional analysis.

[Table 4]

In table 5, we report the effect of R&D on operating performance, depending on firm age. We exclude crisis period while doing DID analysis. Firstly, table 5 shows that at the given level of R&D investment, young firm enjoys higher operating performance than old firms before the crisis, as indicated by the coefficient for R&D interacted with firm age. Before the crisis, investment or capital expenditure yields lower ROA, but it affects higher operating performance after the 2008 crisis; however, a firm enjoys higher ROA out of acquisition and R&D before the crisis, whereas acquisition and R&D after the 2008 crisis yield insignificant and even negative ROA, respectively. Secondly, positive and significant coefficient of age after the 2008 crisis implies that older firm gets higher operating performance in the post-crisis period. Thirdly, at the given level of R&D, younger firm used to yield higher ROA, but its R&D effort yields less operating performance success than older firms after the crisis.

[Table 5]

In table 6, we report the results using Tobin's Q as the dependent variable to see if a firm's innovation effort results in higher market value and if it varies over firm age and in the post-crisis period. The analysis shows that all firm's investment spending (investment, acquisition and R&D) leads to smaller and even negative market value after the 2008 crisis. Age has a negative effect on firm's market value, meaning that older firm has smaller Tobin's Q, which gets more negative in the post-crisis period. However, R&D also changes after the 2008 crisis: it has positive effect on firm value, but the innovation effort out of it has negative effect on post-crisis Tobin's Q. Interacted with age, a positive R&D coefficient implies that the given level of R&D, older firm has positive Tobin's Q out of R&D. the positive coefficient of R&D*AGE*Post indicates that the interaction effects become larger after the post-crisis. All these result support the fact that contrast to conventional belief, old firm's R&D effort has more positive performance result as well as the relevant market value of a firm. Moreover, this fact gets stronger after the 2008 crisis.

[Table 6]

5.1. Robustness Test

As for robustness tests, we test the same analyses on a sample of companies covering four high-tech industries: aerospace and defense (SIC-codes 372 and 376), computers and office machinery (SIC-code 357), pharmaceuticals (SIC-code 283) and electronics and communications (SIC-code 36), following Cloodt et al., 2006). Table 7 shows that profitability from R&D investment gets smaller after the 2008 crisis; Firm age is insignificant in determining a firm's performance, but the given the level of R&D, old firm's profitability is significantly positive, which gets bigger after the 2008 crisis. In terms of innovation effect on a firm's market value, R&D investment negatively affects a firm's market value, or Tobin's Q as it goes through the 2008 crisis; as before, age is insignificant in determining a firm's market value, but the given level of R&D investment, young firm has significantly positive firm value. However, after the 2008 crisis, the result supports our main argument that old firm's market value is significantly bigger. This result also holds when we do the same analysis on innovative industries separately. In sum, in innovative industries, our main result that old firm’s market valuation as well as performance is better than young counterparts, which gets stronger as we go through the financial crisis.

[Table 7]

Additionally, we also apply the method by previous studies to ensure the result of this paper holds if we divide young and old firms differently. Following Duchin et al. (2010), we divide sample at the median and see if our result holds. Also, we classify the sample as young firms when they are less than 8 years old, or until 10 years after IPO. In this paper, we only report the analysis based on Duchin et al (2010), but same result holds if we change dividing the sample differently. In table 8, age is insignificant in determining the level of ROA, but the given level of R&D, old firm's profitability is significantly higher, which gets stronger after the 2008 crisis. The profitability from R&D investment gets negative after the financial crisis. Looking at a firm's market value, at the given level of R&D young firm has higher Tobin's Q, but old firm has higher market value if we control R&D investment after the financial crisis. On the other hand, the benefit from R&D spending on a firm's market value is bigger in the post-crisis period than in the pre-crisis counterpart. In sum, our robustness test supports our main result that contrary to conventional belief, old firm enjoys benefit from innovation, represented by R&D investment in that its market value and performance is better than young counterpart.

[Table 8]

6. Implications and discussion

This study shows that investors evaluate young firms with R&D activities lower than before. Lower valuation comes from that these young innovative firms face a higher probability of financial distress during a crisis and lower profitability. Compared with the pre-crisis, young firms spend less on such innovative activities. Furthermore, they face a larger distress during a financial crisis. Moreover, young innovative firms which are defined as young firms with R&D investment, face higher probability of market exit than old innovative firms. Realizing that firms have to overcome difficulties in innovation activities, investors lower their valuation for young firms' innovation activities, as reflected in lower market value of young innovative firms, and this result gets stronger after the 2008 crisis. Conversely, old firms with high R&D are valued higher than before the crisis, which implies smaller role of small and young firms in innovation and economic growth.

However, it is still too early to argue that a smaller role of young or small firms. Future research requires additional analysis on M&A activities to see if our result is affected by M&A

activities of old firms done before young firms do R&D investment. Moreover, future studies should consider the young and small firms when there is a large technological change. We examine relatively short time period covering 2001-2015. If we examine a longer time period or time period of dramatic innovation and technological changes, our results can be different. As our results suggest that old firms play an important role in R&D activities, there is a need to modify the details of the corporate life cycle hypothesis.

7. Conclusion

Using US publicly listed firms, we empirically test the accounting performance and stock market value of innovative activities such as R&D investment, capital expenses and acquisitions. Using all publicly listed non-financial firms in the US stock markets between 2001 and 2015, we have found that young firms do not necessarily invest more in R&D activities; controlling a firm's financial constraint, old firms significantly spend more on R&D, acquisition, capital expenditure and total investment. Moreover, effects of R&D on profitability are larger in old firms and the effects gets stronger after the 2008 crisis. At the given level of R&D, the result strongly supports our argument that old innovative firms show higher profitability than young counterparts after the 2008 crisis, while young innovative firms only show higher profitability in the pre-crisis period. The effects of R&D on Tobin's Q suggest that R&D spending of young firms are valued lower than before the crisis: Tobin's Q are larger in young firms throughout the period we investigate, but at the given level of R&D, old "innovative" firms hold higher market value than young innovative ones. Finally, young firms are more likely to exit from the market when their R&D spending is larger. During crisis, young firms are more likely to suffer from financial distress when their R&D spending is larger.

In short, young innovative firms face distress and difficulty in external funding during a macro-economic crisis more than old firms. After the crisis, the effects of R&D investment on firm value in the stock market are smaller in young firms than old firms, suggesting investors lower the value of growth option for young innovative firms. In contrast to a conventional belief, our findings suggest the weaker role of young firms in innovative activities after the 2008 crisis.

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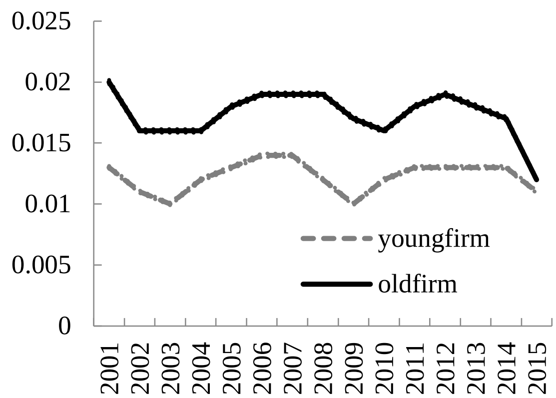
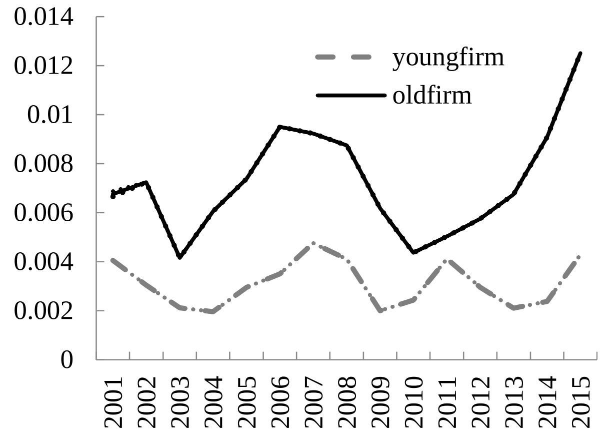
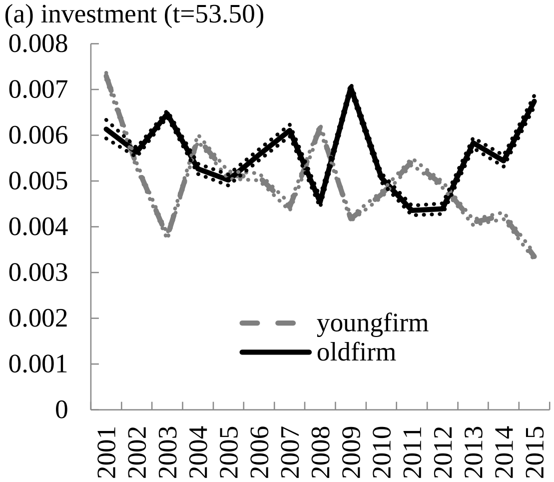


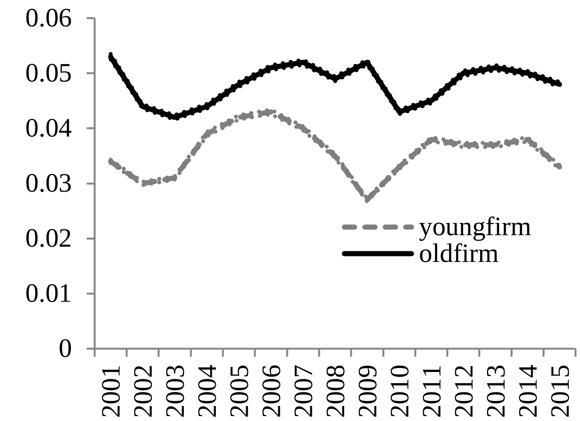
(a) investment (t=53.50)



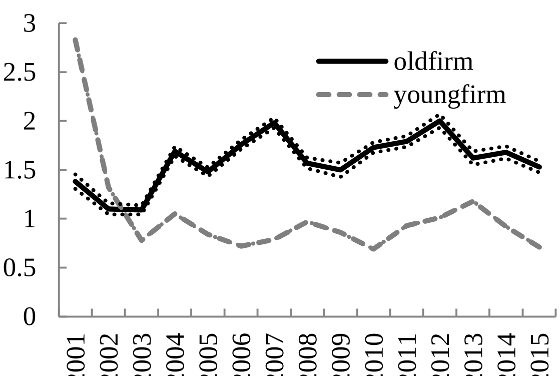
(b) acquisition (t=56.98)



(c) R&D (t=30.66)



(d) total investment (t=42.96)



(e) sales growth (t=100.08)
Old vs young firms

Figure 1. Sales growth, total investment and investment rate of firms classified by age excluding financial firms (SIC code 6000-6999) and utilities (SIC code 4900-4949). Following Duchin et al. (2010), We classify firms with old and young by dividing the sample at the median each quarter using firm size and age. Following Richardson (2006), total investment is the sum of capital expenditure, acquisitions and R&D minus sale of property, plant and equipment. T-tests to show if there is a statistical difference between the two groups are in parentheses. Dotted lines are 95% confidence bands for each subsample. Data come from compustat database.

Table 1: Summary Statistics

This table presents summary statistics of the main variables used in the analysis for the quarterly data from 2001Q3 to 2015Q2. Pre-crisis period refers to the period 2001Q3 to 2007Q2. Crisis period refers to the period 2007Q3 to 2009Q2, and post-crisis period refers to the period 2009Q3 to 2015Q2. We calculate means, medians, standard deviations, minimum and maximum over the entire sample period. Capital expenditure (CAPEX), cash flow, cash holdings are normalized by total assets at the beginning of the quarter. Following Duchin et al. (2010), We classify firms with big (or small) and old (or young) by dividing the sample at the median each quarter using firm size and age

	N	Mean	Median	Std. Dev.	Min	Max	firm size			Firm age		
							Big (n=144,072)	small	t-stat	Old (n=144,180)	young	t-stat
CAPEX/Assets	288,322	0.015	0.007	0.027	-0.002	0.189	0.017	0.014	30.66	0.018	0.012	53.50
R&D	121,713	0.018	0.000	0.041	0.000	0.272	0.006	0.030	-142.26	0.017	0.020	-15.65
Acquisition	58,496	0.005	0.000	0.021	-0.002	0.161	0.006	0.003	41.21	0.007	0.003	51.25
Q	288,322	1.872	1.432	1.388	0.341	8.331	1.517	2.228	-142.28	1.968	1.778	36.79
Cash flow	288,322	-0.013	0.021	0.162	-1.161	0.190	0.033	-0.059	156.99	0.003	-0.029	52.08
Cash	288,322	0.205	0.113	0.228	0.000	0.919	0.141	0.270	-158.94	0.209	0.202	7.94
Age	288,322	22.254	19.000	14.646	1.000	66.000	26.03	18.48	143.09	22.89	18.61	23.34
Sales Growth (SG)	288,322	1.212	0.061	7.784	-0.995	70.182	1.006	1.420	-14.27	2.642	-0.214	100.08
NWC	288,322	-0.133	0.013	0.922	-7.331	0.521	0.037	-0.304	100.94	-0.082	-0.185	30.19
Log (Asset)	288,322	5.218	5.340	2.619	-1.663	10.966	7.310	3.125	713.38	5.395	5.041	36.35
Leverage	288,322	0.321	0.190	0.560	0.000	4.295	0.291	0.351	-28.53	0.285	0.357	-34.36
LT debt	288,322	0.196	0.099	0.269	0.000	1.513	0.252	0.141	113.44	0.187	0.206	-19.37
ST debt	288,322	0.108	0.010	0.371	0.000	3.024	0.038	0.178	-102.83	0.086	0.129	-30.83
Debt issue	288,322	0.006	0.000	0.058	-0.159	0.360	0.004	0.007	-11.99	0.007	0.004	15.67
Equity issue	288,322	0.019	0.000	0.092	-0.076	0.642	0.002	0.035	-98.70	0.018	0.019	-4.31

Table 1.1 Correlation Matrix

This table presents correlation matrix of the main variables used in the analysis for the quarterly data from 2001Q3 to 2015Q2. Pre-crisis period refers to the period 2001Q3 to 2007Q2. Crisis period refers to the period 2007Q3 to 2009Q2, and post-crisis period refers to the period 2009Q3 to 2015Q2 when interest rates are low. Capital expenditure (CAPEX), cash flow, cash holdings are normalized by total assets at the beginning of the quarter. The lower left, diagonal, and upper right matrices contain the correlations, variances, and covariances respectively.

	Investment	RD	ACQ	CF	cash	SG	NWC	size	leverage	LTdebt	STdebt	Debt issue	Equity issue
Investment	0.0007	-0.0002	0.0001	0.0005	-0.0006	0.0369	0.0003	0.0048	-0.0005	0.0003	-0.0003	0.0002	0.0002
RD	-0.0018	0.0017	-0.0001	-0.0027	0.0038	0.0213	-0.0079	-0.0313	0.0019	-0.0007	0.0020	0.0001	0.0011
ACQ	0.0270	-0.0189	0.0004	0.0001	-0.0003	0.0059	0.0006	0.0041	-0.0001	0.0001	-0.0002	0.0002	0.0003
CF	0.0122	-0.4110	0.0460	0.0263	-0.0062	-0.0316	0.0839	0.1918	-0.0367	-0.0014	-0.0281	-0.0015	-0.0056
Cash	-0.1007	0.4088	-0.0670	-0.1684	0.0521	0.0087	-0.0087	-0.1485	-0.0220	-0.0165	-0.0055	-0.0001	0.0046
SG	0.1729	0.0665	0.0360	-0.0250	0.0049	60.5625	-0.1830	-0.6656	0.0996	0.0353	0.0565	0.0186	0.0455
NWC	0.0153	-0.2080	0.0320	0.5608	-0.0417	-0.0255	0.8502	0.9411	-0.3857	-0.0222	-0.2913	-0.0071	-0.0142
Size	0.0669	-0.2899	0.0736	0.4511	-0.2484	-0.0326	0.3897	6.8579	-0.3485	0.0932	-0.3526	-0.0106	-0.0568
Leverage	-0.0033	0.0839	-0.0150	-0.4042	-0.1727	0.0228	-0.7466	-0.2375	0.3139	0.0857	0.1682	0.0061	0.0038
LTdebt	0.0528	-0.0658	0.0244	-0.0327	-0.2701	0.0169	-0.0898	0.1323	0.5688	0.0723	0.0044	0.0027	-0.0008
STdebt	-0.0336	0.1338	-0.0319	-0.4671	-0.0658	0.0195	-0.8515	-0.3629	0.8091	0.0446	0.1376	0.0025	0.0039
Debtissue	0.1461	0.0778	0.2352	-0.1653	-0.0013	0.0414	-0.1340	-0.0701	0.1898	0.1767	0.1172	0.0033	-0.0004
equityissue	0.0912	0.3106	0.0190	-0.3742	0.2212	0.0633	-0.1672	-0.2354	0.0744	-0.0353	0.1139	-0.0081	0.0085

Table 2: Firm Age and Investment before and after the financial crisis

The dependent variable is firm-level quarterly investment or corporate spending from 2001Q3 to 2015Q2. All equations quarterly time dummies and firm dummies. Firm-level variables include Cash, Tobin's Q, Cash Flow and sales growth (SG), property, plant and equipment (PPEA), sale of property, plant and equipment (PPE), leverage, R&D, size, equity issuance and debt issuance following Denis and Sibilikov (2010) (unreported). P-values in parentheses are based on standard errors robust to clustering by firm and quarter. Variable definitions are in the Appendix.

	Inv	R&D	Acquisitions	Total investment
Q	0.0019	0.0023	0.0011	0.0031
	(0.000)	(0.000)	(0.000)	(0.000)
CF	-0.0198	-0.0214	0.0011	-0.0926
	(0.000)	(0.000)	(0.488)	(0.000)
Cash	-0.0047	-0.0180	-0.0404	-0.1098
	(0.000)	(0.000)	(0.000)	(0.000)
SG	-0.0007	0.0003	-0.0002	-0.0001
	(0.000)	(0.003)	(0.162)	(0.000)
lagGDP	0.0007	-0.0008	-0.0003	-0.0001
	(0.007)	(0.006)	(0.923)	(0.098)
salePPE	0.4667	0.0194	0.1236	-0.9346
	(0.000)	(0.352)	(0.000)	(0.000)
PPEA	0.0635	0.0109	-0.0059	0.0800
	(0.000)	(0.000)	(0.000)	(0.000)
leverage	-0.0022	0.0022	0.0018	0.0042
	(0.000)	(0.000)	(0.000)	(0.000)
size	0.0118	-0.0186	0.0094	0.0379
	(0.000)	(0.000)	(0.000)	(0.000)
Equityissue	0.0136	-0.0112	0.0167	0.1123
	(0.000)	(0.000)	(0.000)	(0.000)
Debtissue	0.0387	0.0004	0.0815	0.2837
	(0.000)	(0.963)	(0.000)	(0.000)
Age	-0.0448	9.0829	7.9566	2.1394
	(0.463)	(0.006)	(0.000)	(0.000)
CF*age	0.0004	0.0001	0.0020	0.0009
	(0.000)	(0.198)	(0.031)	(0.000)
Interaction with POST-crisis dummy				
Q	-0.0016	0.0002	-0.0003	-0.0025
	(0.000)	(0.271)	(0.111)	(0.000)
CF	0.0009	0.0116	0.0022	-0.0158
	(0.146)	(0.000)	(0.302)	(0.005)
Cash	-0.0019	0.0004	-0.0134	-0.0201
	(0.146)	(0.739)	(0.000)	(0.000)
SG	0.0002	-0.0009	0.0004	0.0001
	(0.154)	(0.620)	(0.840)	(0.008)
lagGDP	-0.0001	0.0007	0.0005	0.0009
	(0.001)	(0.104)	(0.261)	(0.454)
salePPE	-0.0952	-0.1130	0.0099	-0.0859
	(0.006)	(0.001)	(0.802)	(0.414)
PPEA	0.0016	-0.0042	-0.0048	-0.0174
	(0.461)	(0.064)	(0.054)	(0.008)
leverage	-0.0015	-0.0010	0.0005	-0.0057
	(0.002)	(0.045)	(0.353)	(0.000)
Size	-0.0046	-0.0049	0.0028	-0.0045
	(0.000)	(0.000)	(0.000)	(0.001)
Equityissue	0.0013	-0.0038	0.0013	0.0039
	(0.230)	(0.001)	(0.290)	(0.249)
debtissue	0.0035	0.0050	0.0216	0.0523
	(0.028)	(0.002)	(0.000)	(0.000)
Age	-0.0023	-0.0033	-0.0014	-0.0071
	(0.454)	(0.271)	(0.840)	(0.414)
CF*age	0.0002	-0.0006	-0.0001	0.0005
	(0.008)	(0.137)	(0.368)	(0.000)
R square	0.65	0.80	0.36	0.63
N obs	248,762	248,762	248,762	248,762

Table 3. R&D and Financial Distress of Firms in Crisis Period

The specifications have a binary dependent variable equal to 1 in the period if a firm is financially distressed and 0 otherwise, following Hill et al. (2010) and Aktas et al. (2015). The table shows marginal effects as in Fernandes and Paunov (2015): for dummy variables the marginal effect is the change in the probability of exit associated with a change in the variable from 0 to 1 and for continuous variables the marginal effect is the marginal change in the probability of exit associated with a change in the variable evaluated at the means of other variables. The regressors are defined in Appendix.

Variable	Coeff	p-value
Age	-0.4485	0.042
R&D	0.0005	0.176
R&D*age	-1.1559	0.000
Sales growth	1.0886	0.000
Capital intensity	-0.0005	0.710
Firm size	-1.8688	0.000
Firm size squared	0.1119	0.002
Firm initial size	0.0001	0.672
Firm initial size squared	-1.5785	0.008
Industry sales growth	-0.7868	0.123
Industry herfindahl index	-0.2061	0.000
Industry herfindahl index squared	0.1832	0.002
4-digit industry fixed effects	Yes	
Year fixed effects	Yes	
Log-likelihood	-9,417	

Table 4. R&D, Firm Age and Firm Exit in 2001-2015

The specifications have a binary dependent variable equal to 1 in the period of exit for firms that exit and 0 otherwise. The table shows marginal effects as in Fernandes and Paunov (2015): for dummy variables the marginal effect is the change in the probability of exit associated with a change in the variable from 0 to 1 and for continuous variables the marginal effect is the marginal change in the probability of exit associated with a change in the variable evaluated at the means of other variables. The regressors are defined in Appendix.

Variable	Coeff	p-value
Age	-0.7957	0.015
R&D	-0.4097	0.064
R&D*age	0.0588	0.000
R&D*crisis	0.0518	0.000
R&D*crisis*age	0.0082	0.000
R&D*post	0.0095	0.000
R&D*post*age	0.0019	0.008
Sales growth	-0.5012	0.013
Capital intensity	-0.5792	0.100
Firm size	-0.6681	0.000
Firm size squared	0.9720	0.000
Firm initial size	-0.1382	0.337
Firm initial size squared	0.5035	0.875
Industry sales growth	-0.6092	0.596
Industry herfindahl index	-0.6054	0.128
Industry herfindahl index squared	0.1655	0.337
industry fixed effects	Yes	
Year fixed effects	Yes	
Log-likelihood	-6,635	

Table 5. The Effects of R&D and Firm Age on Operating Performance

This table reports the fixed effects operating performance regressions. The dependent variable is the return on assets (ROA) in year t. The independent variables are lagged by one period with respect to the dependent variable. Variable definitions are provided in Appendix. Standard errors are robust and clustered at firm level, following Aktas et al. (2015).

Variable	Coeff	p-value
Investment	-1.9960	0.006
ACQ	2.7945	0.000
NWC	-2.2878	0.000
Size	-3.0078	0.000
Intangible assets	0.0003	0.238
Leverage	1.2500	0.000
Age	0.0010	0.962
R&D	8.2761	0.000
Risk	0.0008	0.307
Fixed asset growth	4.1110	0.000
Cash	1.3063	0.000
Sales volatility	-0.0029	0.318
CF	2.3490	0.000
Financial distress	0.0973	0.171
Sales growth	0.0005	0.413
RD*age	-0.4867	0.000
Interaction with post-crisis dummy		
Investment	1.3586	0.028
ACQ	0.7768	0.421
NWC	-0.5377	0.000
Size	-1.3046	0.000
Intangible assets	-0.0002	0.939
Leverage	-1.0661	0.000
Age	0.0298	0.010
R&D	-10.6260	0.000
Risk	-0.0005	0.634
Fixed asset growth	-5.1397	0.000
Cash	-2.4323	0.000
Sales volatility	-0.0157	0.000
CF	1.2848	0.000
Financial distress	-0.0030	0.976
Sales growth	-0.0004	0.457
RD*age*post	0.8630	0.000
R	0.84	

Table 6. The Effects of R&D and Firm Age on its Market Value

This table reports the fixed effects operating performance regressions. The dependent variable is Tobin's Q in year t. The independent variables are lagged by one period with respect to the dependent variable. Variable definitions are provided in Appendix. Standard errors are robust and clustered at firm level, following Aktas et al. (2015).

Variable	Coeff	p-value
Investment	1.2198	0.000
ACQ	0.4673	0.000
NWC	-0.2673	0.000
Size	-0.6109	0.000
Intangible assets	0.0001	0.000
Leverage	0.0329	0.000
Age	-0.0328	0.000
R&D	0.9021	0.000
Risk	0.0004	0.000
Fixed asset growth	-0.1094	0.001
Cash	0.4398	0.000
Sales volatility	-0.0017	0.000
CF	-0.2644	0.000
Financial distress	0.0560	0.000
Sales growth	-0.0003	0.642
RD*age	0.0082	0.075
Interaction with Post-crisis dummy		
Investment	-1.0748	0.000
ACQ	-0.2690	0.007
NWC	0.0114	0.155
Size	0.0134	0.248
Intangible assets	-0.0001	0.000
Leverage	-0.0399	0.000
Age	-0.0429	0.000
R&D	-0.2036	0.036
Risk	-0.0002	0.025
Fixed asset growth	0.0028	0.957
Cash	-0.0991	0.002
Sales volatility	-0.0012	0.002
CF	-0.0463	0.081
Financial distress	-0.0318	0.003
Sales growth	0.0002	0.710
RD*AGE*post	0.0225	0.038
R	0.78	

Table 7. The Effects of R&D and Firm Age on ROA and Q in Innovative Industries

This table reports the fixed effects operating performance regressions. The dependent variable is Tobin's Q, and return on assets (ROA) in year t. The independent variables are lagged by one period with respect to the dependent variable. Variable definitions are provided in Appendix. Standard errors are robust and clustered at firm level, following Aktas et al. (2015). Following Cloodt et al. (2006), we test the analyses on a sample of companies covering four high-tech industries: aerospace and defence (SIC-codes 372 and 376), computers and office machinery (SIC-code 357), pharmaceuticals (SIC-code 283) and electronics and communications (SIC-code 36).

Variable	Coeff	p-value
Dependent variable: ROA		
Investment	0.6097	0.000
ACQ	0.4952	0.001
NWC	-0.2708	0.000
Size	-0.5443	0.000
Intangible assets	0.0002	0.035
Leverage	-0.3124	0.338
Age	-0.0014	0.375
R&D	1.0577	0.000
Risk	0.6197	0.002
Fixed asset growth	-0.0046	0.000
Cash	0.2116	0.000
Sales volatility	-0.0547	0.000
CF	-0.0007	0.000
Financial distress	0.0171	0.000
Sales growth	-0.0859	0.323
RD*age	0.0566	0.000
RD*post	0.0486	0.001
RD*age*post	0.1139	0.090
Dependent variable: Tobin's Q		
Investment	-3.0737	0.000
ACQ	1.3385	0.004
NWC	-2.5766	0.000
Size	-3.8166	0.000
Intangible assets	0.9073	0.338
Leverage	0.1347	0.000
Age	0.1876	0.375
R&D	8.3682	0.000
Risk	0.1607	0.323
Fixed asset growth	2.6220	0.000
Cash	0.4372	0.400
Sales volatility	-0.7544	0.246
CF	-2.8034	0.000
Financial distress	0.1966	0.073
Sales growth	0.1449	0.298
RD*age	-0.5263	0.000
RD*post	-9.5666	0.000
RD*age*post	0.9579	0.000
R	0.79	

Table 8. The Effects of R&D and Firm Age on ROA and Q by dividing the sample at the median

This table reports the fixed effects operating performance regressions. The dependent variable is Tobin's Q, and return on assets (ROA) in year t. The independent variables are lagged by one period with respect to the dependent variable. Variable definitions are provided in Appendix. Standard errors are robust and clustered at firm level, following Aktas et al. (2015). Following Duchin et al. (2010), we divide the sample as old versus young at the median.

Variable	Coeff	p-value
Dependent variable: ROA		
Investment	0.2198	0.000
ACQ	0.4673	0.000
NWC	-0.2673	0.000
Size	-0.6109	0.000
Intangible assets	0.0001	0.000
Leverage	0.0329	0.000
Age	-0.0328	0.283
R&D	0.9021	0.000
Risk	0.0004	0.000
Fixed asset growth	-0.1094	0.001
Cash	0.4398	0.000
Sales volatility	-0.0017	0.000
CF	-0.2644	0.000
Financial distress	0.0560	0.000
Sales growth	-0.0003	0.642
RD*age	0.0082	0.075
RD*post	-0.2036	0.036
RD*age*post	0.0225	0.038
Dependent variable: Tobin's Q		
Investment	0.8058	0.000
ACQ	0.3750	0.000
NWC	-0.2576	0.000
Size	-0.6178	0.000
Intangible assets	0.0003	0.051
Leverage	-0.0277	0.000
Age	-0.0652	0.578
R&D	0.8598	0.000
Risk	0.0008	0.000
Fixed asset growth	-0.0973	0.017
Cash	0.5735	0.000
Sales volatility	-0.0021	0.000
CF	-0.2952	0.000
Financial distress	0.0620	0.000
Sales growth	-0.0009	0.561
RD*age	-3.7655	0.060
RD*post	1.5232	0.000
RD*age*post	4.1854	0.057
R	0.74	

Appendix: Variable Definitions

Variable	Definition
Acquisitions	Acquisition / book assets
Cash	Cash and short-term investments / lagged total assets.
Cash Flow(CF)	Operating income before depreciation / lagged total assets.
Credit spread	The difference between the AAA and BBB yields published by the Federal Reserve.
Dividends (D)	Common dividends
Dividend dummy	It is one in quarters in which a firm pays a common dividend.
Earnings (E)	Earnings before extraordinary items + interest + income statement deferred tax credits + investment tax credits
Exit	Variable equals 1 if the firm is in the sample in year t but not in year t+1, and 0 otherwise
Firm Initial Size	Logarithm of the total assets in its initial year in the sample (from 1979 onwards)
Firm Capital Intensity	The ratio of net fixed assets to sales
Interest (I)	Interest expense
Industry Sigma	The mean of the standard deviations of cash flow / assets over 10 years for firms in the same, 2-digit SIC code industry
Industry Herfindahl	H*=(H-1/N)/(1-1/N) where H is the Herfindahl index computed as the sum of the squares of the market shares of all N firms in the 2-digit SIC industry and year. H* ranges from 0 to 1 with larger values indicating higher concentration
Investment	Quarterly capital expenditure / lagged total assets[1].
Leverage	(Long-term debt + debt in current liabilities) / book assets
Loss dummy	It is one if net income is less than zero, and zero otherwise
Net Assets (NA)	Net assets, calculated as book value of total assets – cash
NWC	Net working capital (current assets – current liabilities – cash) / total assets.
R&D	Research and development expense or zero when missing
R&D to sales	R&D expense / sales
Size	Log(total assets).
Tobin's Q(Q)	Market value of assets (total assets + market value of common equity (common shares outstanding*price close) – book value of common equity – deferred taxes) / (0.9*book value of assets + 0.1* market value of assets).

[1] For year-to-date items such as capital expenditure, we subtract the previous quarter's capital expenditure from the current quarter's for fiscal quarters, 2, 3, and 4. The same adjustment is applied for other year-to-date items.