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Effect of Innovation on Profitability and Firm Value: The Post 2008 Crises in the United States

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Abstract

The broad objective of this study was to investigate the effect of innovation on profitability and firm value after 2008 crises of the US firms. Explicitly, we examined the effect of firm age, and research and development (R&D) activities on profitability and firm value, using publicly traded non-financial US firms between 2000 and 2016, We applying R&D investment as our main innovation measure. Our result shows that old firm innovation is higher than young competitors. However, young innovative firm enjoys higher market value and profitability than old counterparts, indicating that investors appreciate the value of growth option for young innovative firms higher than before. Moreover, old innovative firms face higher market exit risk than young firms after the 2008 crisis. Despite the post-crisis performance, young innovative firms still expose themselves to financial distress risks.

Key words: R&D investment, firm age, innovation, profitability, stock market value
JEL Classification Code: G01, G3

Introduction

Do entrant firms make major innovations? Does firm performance depend on age and innovation level? These questions were found in several studies of which the results were often conflicting. According to previous studies, new firms make important changes thus, making existing knowledge obsolete (Bergek, Berggren, Magnusson & Hobday, 2013; Criscuolo, Nicolaou & Salter, 2012; Akcigit & Kerr, 2010). In line with the second question, some studies find a negative effect of age on growth: young firms show a higher growth of productivity and sales (Lotti, Santarelli & Vivarelli 2009; Geroski & Gugler, 2004). According to Rodriguez, Molina, Perez and Hernandez (2003), asset growth in small and medium-sized firms gets lower when firm age becomes older.

Other studies explore market investors who react positively to larger R&D spending especially in small or young firms. For instance, using data in 1990s, Lee and Chen (2009) argue that investors evaluate more optimistically smaller firms that are likely to be more innovative. Given that stock market valuation includes value of growth options (Chan, Lakonishok & Sougiannis, 2001), young innovative firms tend to have higher market value, even though young firms often show low profitability (Hall & Lerner, 2010).

However, previous studies suggest that young U.S. firms do not invest more in innovative activities than old counterparts. Due to frictions in financial markets, young firms with low profitability often find it difficult to finance their investment (Alti, 2003), so young firm investments are volatile and more sensitive to their cash flows or cash holdings than those of mature firms (Alti, 2003; Brown & Petersen, 2011). In addition, the 2008 financial crisis further exacerbates such financial market frictions that existed after the dot-com bubble burst in the early 2000, but seldom have they addressed the question of whether innovation effort and subsequent performance change after the aggregate shock.

Furthermore, past studies suggest a moderating effect of firm age on the innovation-performance relationship. Facing difficulty in turning knowledge into innovative activities (Calantone, Cavusgil & Zhao, 2002), young firms often show lower productivity in innovation activities than mature competitors (Van Praag & Versloot, 2007; Nightingale & Coad, 2013). For example, patent citations in U.S. semiconductor and biotechnology firms increase with firm age (Sorensen & Stuart, 2000). Old incumbent firms show a higher productivity growth and play a major role in industry productivity growth than young counterparts (Bartelsman & Doms, 2000).

On the other hand, some studies have provided conflicting views studies on the effectiveness of innovative activities of young firms, but few studies have systematically examined how the innovative activities affect firm performance, considering firm age. For example, using a survey data on Spanish manufacturing firms, Coad, Segarra and Teruel (2016) examined firm activities such as sales, productivity, or employment. However, they do not examine the impact of R&D by young and old firms on firm profitability or market values.

Using publicly traded non-financial firms in the US stock markets between 2000 and 2016, we empirically investigate the impact of innovative activities of young and mature firms on corporate profitability and market value. These performance variables are suitable to examine the relationship between innovation and economic growth and are more directly related to long term survival and growth of firms. In addition, we examine how the effect of firm age on firm performance varies after the 2008 financial crisis during which young innovative firms face a higher probability of funding difficulties.

Looking at four types of investment, which are capital expenditure (CAPEX hereafter), R&D, acquisition and total investment, we find that old firms invest more in those investments than young competitors after the financial crisis. Old firms significantly spend more corporate resources on R&D and total investment than young firms, even when we control for financial constraint in the post-crisis period. However, the profitability of young innovative firms is higher, which continues to a lesser degree after the crisis in certain types of investment. Especially, the market value of young firm is higher than mature firms both in pre- and post-crisis periods, which gets stronger after the 2008 crisis. These results suggest that old firms play an important role in innovation, but it is not reflected in firm performance and in the market. Finally, young innovative firms are more likely to suffer from market exit and financial distress risks before the 2008 crisis, but mature competitors are more likely to exit in the post-crisis period. Still, though weakly supported, young innovative firms expose themselves to financial distress after the 2008 crisis.

Our main results are robust when we classify young versus old firms differently and when we use different proxies for innovative activities. Those results are consistent when we focus our analyses on high R&D industries as well. One, our results remain the same when we define young firms as those belong to bottom 30% of firm age and those with less than 5 years after IPO (Covin, Slevin & Covin, 1990; Zahra, 1996). We obtain similar results when we classify firms as those belong to the lower half of median age in the sample (Duchin, Ozbas & Sensoy, 2010). Two, measuring innovative activities through CAPEX, acquisitions and total investment yields similar results as R&D investments from firm exit risk and firm value after the 2008 crisis. As firms access external knowledge and promote innovation through acquisitions (Hohberger, Almeida & Parada, 2015; Sevilir & Tian, 2012), we also apply acquisitions as an innovation measure. As in Hirshleifer, Hsu and Li (2013), we control for capital expenditure, since it is found to explain operating performance (Pandit, Wasley & Zach, 2009), to accommodate persistence in operating performance (Gu, 2005) and to the mean reversion in profitability (Fama & French, 2000). Three, our main results also hold in industries with high R&D activities following Cloodt, Hagedoom and Kranenburg (2006), which includes computers and office machinery, aerospace and defense, pharmaceuticals, and electronics and communications. Even in such innovative industries, effects of R&D investment on market value are bigger for young firms than old ones, and old innovative firms suffer from survival risk after the 2008 crisis.

Our paper is organized as follows. Section 2 discusses prior research on the firm age and corporate innovative activities. 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.

Literature Review and Hypotheses Development

a) Conceptual Review

To quantify a firm's innovativeness, we use R&D spending over asset (Koga, 2005; Castany, López-Bazo & Moreno, 2005; Yang & Huang, 2005), acquisition, and total investment as well as capital expenditure to accommodate operating performance. As for R&D measure, we also did additional robustness test using R&D-to-sale ratio to make sure that changing the denominator does not change our result. As previous literature shows that firms find it difficult to invest when they face financial constraint, the equation includes interaction terms between firm Age with cash flow (CF).

Additionally, firm-level control variables include firm size, leverage, Cash, Tobin's Q, sales growth (SG) measured through the year-on-year percentage change, property, plant and equipment (PPEA), sale of property, plant and equipment (sPPE), and equity issuance and debt issuance following Denis and Sibilikov (2009). To control for overall macroeconomic conditions, we use lagged values of change in quarterly GDP growth as well, as in Gulen and Ion (2015). All variables are described in table 1 below.

Table 1: Variable Definitions

Variable	Definition
Acquisitions	Acquisition / book assets
BVETB	Book value of equity / total liabilities (Altman, Iwanicz-Drozdowska, Laitinen & Suvas, 2014)
CAPEX	Capital expenditure / total assets. We subtract the previous quarter's capital expenditure from the current quarter's capital expenditure as well as other variables reported on year-to-date basis, following Duchin et al. (2010).
Cash	Cash and short-term investments / total assets.(Duchin, Ozbas & Sensoy 2010)
Cash Flow(CF)	Operating income before depreciation / total assets. (Duchin et al., 2010)
Debt Issuance	Long term debt issuance net of reduction / total assets (Denis & Sibilikov, 2009)
EBITTA	Earnings before interest and tax / total assets (Altman, 2014)
Equity Issuance	One period change in the number of stocks outstanding, adjusted for stock splits multiplied by the fiscal year close price (Denis & Sibilikov, 2009)
Exit	Variable equals 1 if the firm is in the sample in year t but not in year t+1, and 0 otherwise
Financial Distress Dummy	1) operating income before depreciation divided by interest expense is below one for two consecutive years or less than 0.80 in any given year. 2) The firm is considered to be overleveraged if it is in the top two deciles of industry leverage in a given year (Hill, Kelly & Highfield, 2010; Aktas, Croci & Petmezas, 2015)
Fixed Asset Growth	Change in net property, plant and equipment (Claessens & Laeven, 2003)
Industry Cash Flow Risk (Risk)	Standard deviation of industry cash flow to assets (Bates & Stulz, 2009)
Intangible asset	Intangible asset / total asset (Claessens & Laeven, 2003)
Leverage	Total liabilities / book assets (Duchin et al., 2010)
NWC	Net working capital (current assets – current liabilities – cash) / total assets (Duchin et al., 2010)
PPEA	Property, plant and equipment (Total, Net) / total assets (Denis & Sibilikov, 2009)
R&D	Research and development expense or zero when missing / total assets
RETA	Retained earnings / total assets (Altman, 2014)
ROA	Net income before extraordinary items / total asset, following Louis and Robinson (2005)
Sales Volatility	Rolling six periods standard deviation of sales growth (Minton & Schrand, 1999)
Size	Log(total assets) (Francis & Yu, 2009)
sPPE	Sale of PP&E / total asset (Denis & Sibilikov, 2009)
Tobin's Q(Q)	Market value of assets (total assetse + 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), following Duchin et al. (2010)
WCTA	Working capital / total assets (Altman, 2014)

Using the four innovation measures in table 1, which are R&D, acquisition, total investment and capital expenditure, we examine whether firm age affects corporate investment in innovative activities. In figure 1 (c), we show that R&D investment of young firms are in a downward trend in 2001-2015, whereas that of old competitors is rather stable, which motivates us to see which firm investment in R&D is smaller than the other. Thus, we argue that firm age affects firm investment. We also investigate other types of investment, including CAPEX, acquisition and total investment in order to see if firm investment for growth differs depending on firm age. We hypothesize that the effect of firm age on innovative activities exist even after controlling for volatility in cash flows, or financial constraint, based on previous literature.

As firms face financial distress and funding difficulties during the financial crisis in 2008, firms have changed their investment in innovation. So, we hypothesize that after experiencing a crisis, young or old firms invest less in R&D activities controlling for other factors including funding difficulties along with other financial variables, if young or old firms are considered to be more financially constrained than the other.

H1A: Young/old firms invest less in R&D activities than old/young firms.

H1B: Young/old firms invest less in R&D activities than old/young firms after the 2008 crisis.

Second, we examine the effect of firm investment on corporate profitability and market value. If young or old firms are less efficient in innovation and thus investors appreciate the growth option value of the other firm less than before, we postulate that the effects of R&D investment of the firm age category on profitability and market value are smaller than the other. This leads to our second hypothesis.

H2A: The effects of R&D activities of young/old firms on firm profitability and market value are smaller

H2B: Such negative effects of R&D activities of young/old *firms are stronger especially after the 2008 crisis.*

Finally, we examine why young or old firm invests less in R&D activities or growth options after the 2008 crisis. Among many difficulties that a firm confronts with, we focus on financial distress and market exit after the market experiences a crisis. We test whether an innovative firm face a higher probability of financial distress after the 2008 crisis, or that of exit during 2000-2016, based on firm age. This leads to our third hypothesis:

H3: Young/old innovative firms face higher probability of financial distress or exits after a crisis.

b) Theoretical Review

The economic literature has developed two learning models on how firm age matters in innovation. Both passive learning (Jovanovic, 1982) and active learning models (Ericson & Pakes, 1995) suggest that surviving firms would show higher productivity as they become older even though they start with different initial conditions. However, recent studies challenges view since older firms are liable to experience some form of inertia, which may prevent them from the learning effect (Majumdar, 1997). This study is anchored on the latter theory since old firms at the forefront are quickly supplanted by new ventures due to the ephemerality of modern technological leadership.

c) Review of Empirical Studies

The empirical literature has found both negative and positive effects of firm age on innovation. First, young firms can underperform old firms in innovation. Young firms often face difficulties associated with lack of market recognition, lack of alliances with partners, and lack of ability to turn knowledge into innovation (Calantone et al. 2002). Young firms also suffer from lack of economies of scale. 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). As firms get older, old firms have better organizational structure for facilitating knowledge transfer (Argote, 1999), new product development (Hansen, 1999; Sivadas and Dwyer, 2000) and innovative outcomes (Tripsas and Gavetti, 2000). 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. Moreover, Malamud and Zucchi (2019) show that financing frictions reduce the growth contribution of young firms but spurring that of old firms. Brav et al. (2018) illustrates hedge fund activism or pressure from the stock market encourages old firm innovation. Gonzalez-Uribe (2019) recognizes that the successful commercialization of young companies' innovation requires the inventor's knowhow to be combined with other innovation resources, but the challenge exists in the many market frictions.

However, some empirical evidence show that firm age is negatively related to innovation. Sorensen and Stuart (2000) observe that even though accumulated experience and growth increase with age, older firms find it difficult to keep pace with incessant external technological developments and become obsolete. At one extreme, accumulated experience enables old firms to innovate more frequently, having greater significance than those of young competitors. However, 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. Islam and Zein (2019), emphasizing the role of inventor CEOs associated with higher quality innovation, show that inventor-CEO-run firms are younger in age. However, their analyses focus on innovation dispersion in technological industries before 2000. Overall, these studies suggest that young firms perform better in innovative activities.

Coad et al. (2013) shows how firm performance changes with age, suggesting that new firms have lower productivity than incumbents. Later, Coad et al. (2016) further shows the evidence of benefits from R&D of young firms, measured by firm growth, is risker, whereas the growth effects of old firms are more predictable and stable. Besides, Begenau, Farboodi and Veldkamp (2018) explain that the use of big data in financial markets enables large firms with a longer firm history grow larger, since that data can better reduce the risk of equity investment of those firms, but they mainly look at firm size but not firm age. Our understanding of the role of age on innovative activity is still lacking, since previous studies do not take how stock market investors perceive firm performance or firm value depending on firm age. To examine the relationship between innovation and economic growth, we believe that firm profitability and firm market values are suitable measure, since those measures are more directly related to long term survival and growth of firms. By analyzing profitability and market value, we are in a position to assess this relationship in firm performance in the stock market. Later we show that this study negates the benefit of innovation experience depending on firm age, since our evidence shows that old firms hold higher market exit risk after the financial crisis.

Besides, the evidence on the impact of financial crisis on firms' innovation profiles is scarce. By exploring Latin American countries, Paunov (2012) shows that rising financial constraints and negative demand shock led by the 2008 crisis caused firms to stop ongoing innovation projects. This study agrees with Paunov (2012) since negative demand shock leads to higher risk exposure to firms with higher innovation activities. However, Paunov (2012) investigates relatively short period of time, and the long term impact of the financial crisis needs to be considered to know how business innovation capacities were affected.

Methodology

We use quarterly financial statements on publicly traded, non-financial U.S. firms available on Compustat database from 2000 to 2016. As corporate financing or investing activities vary over fiscal quarters, using quarterly data can provide more accurate information firms' R&D spending, investment decisions and market value. Using the quarterly financial information on Compustat database, Shin and Kim (2002) find that corporate investment is significantly higher in the fourth quarter than other periods. Additionally, using quarterly data provide us with a timelier source of stock market valuation than annual data. Ottonello and Winberry (2018) also draw firm-level variables from quarterly Compustat out of three advantages: a high enough frequency, a panel to use within-firm variation and rich balance-sheet information.

We first get the data of US publicly traded firms from Compustat database. Then, we exclude financial firms and utilities with SIC codes of 4900-4949 and 6000-6969. Following Gulen and Ion (2015), 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 353,922 out of 725,097 firm-quarter observations. For analysis, we use SAS software.

As for classifying young and old firms, we adopted three classification methods. One, we define the top and bottom 30% out of firm age group as old (established) and young firms, respectively. Here we define firm age as the number of years since the firm's initial appearance in Compustat database with non-missing financial information (Rosenbusch, Brinckmann & Bausch 2011). Second, following Duchin et al (2010), we classify firms as old and young by dividing the sample at the median firm age in each quarter. Lastly, we classify the sample as young firms when they are less than 5 years after IPO (Covin, Slevin & Covin, 1990; Zahra, 1996). Regardless of the classification methods, our results are very similar.

Using quarterly financial statements, we explore several proxies for corporate innovative activities. For innovative activities, we use R&D expenses as our main measure (Koga, 2005; Castany, López-Bazo & Moreno, 2005; Yang & Huang, 2005), corporate acquisitions (Hohberger, Almeida & Parada, 2015; Sevilir & Tian, 2012), and capital expenditure to accommodate operating performance (Hirshleifer, Hsu & Li, 2013) as well as total investment. R&D intensity is the research and development expenses scaled by total assets (Brav, Jiang & Tian, 2018). Acquisition is acquisition divided by total assets; CAPEX is quarterly capital expenditure to total assets. Following Richardson (2006), total investment is the sum of capital expenditure, acquisition and R&D expenses minus sale of property, plant and equipment, divided by total assets. Following Bates, Kahle and Stulz (2009), we replace missing R&D and acquisition variables with zero. 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 table 8.

We define the beginning of the financial crisis as the third quarter of 2007, as in Duchin et al. (2010) and Kahle and Stulz (2013), and the ending as the second quarter of 2009. We begin our main sample in the third quarter of 2000 in order to equally divide the main sample period into pre-crisis period (from the first quarter of 2000 to the second quarter of 2007) and post-crisis period (from third quarter of 2009 to the second quarter of 2016) when the interest rates are low. Throughout the analysis, we exclude the crisis period between 2007Q3 and 2009Q2 for the sake of comparison between pre- and post-crisis.

Next, we present empirical estimation methods: we try to test how corporate age of innovative firms affects investment in innovative activities and firm performance. First, we examine whether young firms invest more in innovative activities and whether such relationship has changed after the 2008 crisis. Second, 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 innovation activities using equations similar to investment models in other literature (Erickson & Whited, 2006; Gulen & Ion, 2015; Denis & Sibilikov, 2009). We include firm age into the equation as follows:

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

where $Innovation_{i,t}$ is measured as investment in innovation activity scaled by total assets.

To quantify a firm's innovativeness, we use R&D spending over asset (Koga, 2005; Castany, López-Bazo & Moreno, 2005; Yang & Huang, 2005), acquisition, and total investment as well as capital expenditure to accommodate operating performance. As for R&D measure, we also did additional robustness test using R&D-to-sale ratio to make sure that changing the denominator does not change our result. As previous literature shows that firms find it difficult to invest when they face financial constraint, the equation includes interaction terms between firm Age with cash flow (CF). CF refers to cash flow-to-asset ratio as in table 1. In equation (1), β_1 coefficient for *Age* measures the effect of firm age on investment in innovative activities. If β_1 is significantly positive, it supports our first hypothesis that young or old firms invest less than the other category. Moreover, coefficient for its interaction terms with CF and post-crisis dummy (Post), 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, controlling for financial constraint.

$M_{i,t-1}$ is a vector of lagged values of firm-level control variables which include firm size, leverage, Cash, Tobin's Q, sales growth (SG) measured through the year-on-year percentage change, property, plant and equipment (PPEA), sale of property, plant and equipment (sPPE), and equity issuance and debt issuance following Denis and Sibilikov (2009). To control for overall macroeconomic conditions, we use lagged values of change in quarterly GDP growth as well, as in Gulen and Ion (2015). γ_i is firm fixed effect, and α_t represents a set of fiscal and calendar-quarter dummies.

Second, we examine the effects of young innovative firms on corporate accounting performance and stock market value. Based on Armstrong and Vashishtha (2012) and Bøler, Moxnes and Ulltveit-Moe (2015), we study the impact of firm age and its innovation activities on firm performance.

$$V_{i,t} = \beta_1 Age + \beta_2 R\&D + \beta_3 Age \cdot R\&D + \beta_4 R\&D \cdot post + \beta_5 R\&D \cdot Age \cdot post + \delta_1 \cdot controls_{i,t-1} + \alpha_t + \gamma_i + \varepsilon_{i,t} \quad (2)$$

For dependent variable, we use Tobin's Q and return-on-asset (ROA henceforth) to estimate the firm's market value and operating performance, respectively. In equation (2), β_1 coefficient for *Age* measures the effect of firm age on firm performance. Coefficients β_2 measure the effect of R&D activities on firm performance. Coefficients for *Age* interaction terms with R&D measure the additional effect of *Age*, given the level of R&D on firm performance. Interaction term of $Age \cdot R\&D$ with Post measures how the effect changes in the post-crisis period. Thus, if β_5 is significantly different from zero, the interaction term of firm age and R&D has a significantly different effect on firm value investment in the post-crisis periods. In addition to R&D, we use other three types of variables, CAPEX, acquisition and total investment to see how those investments affect profitability and firm value. For control variables, we include size, leverage, net working capital, intangible assets, industry cash flow risk, fixed asset growth, cash, sales volatility, cash flow, sales growth and financial distress dummy.

Finally, we test whether young innovative firms face higher probability of financial distress and exits during the 2008 financial crisis. We use probit regressions to estimate the effect of R&D innovation on funding difficulty or firm survival:

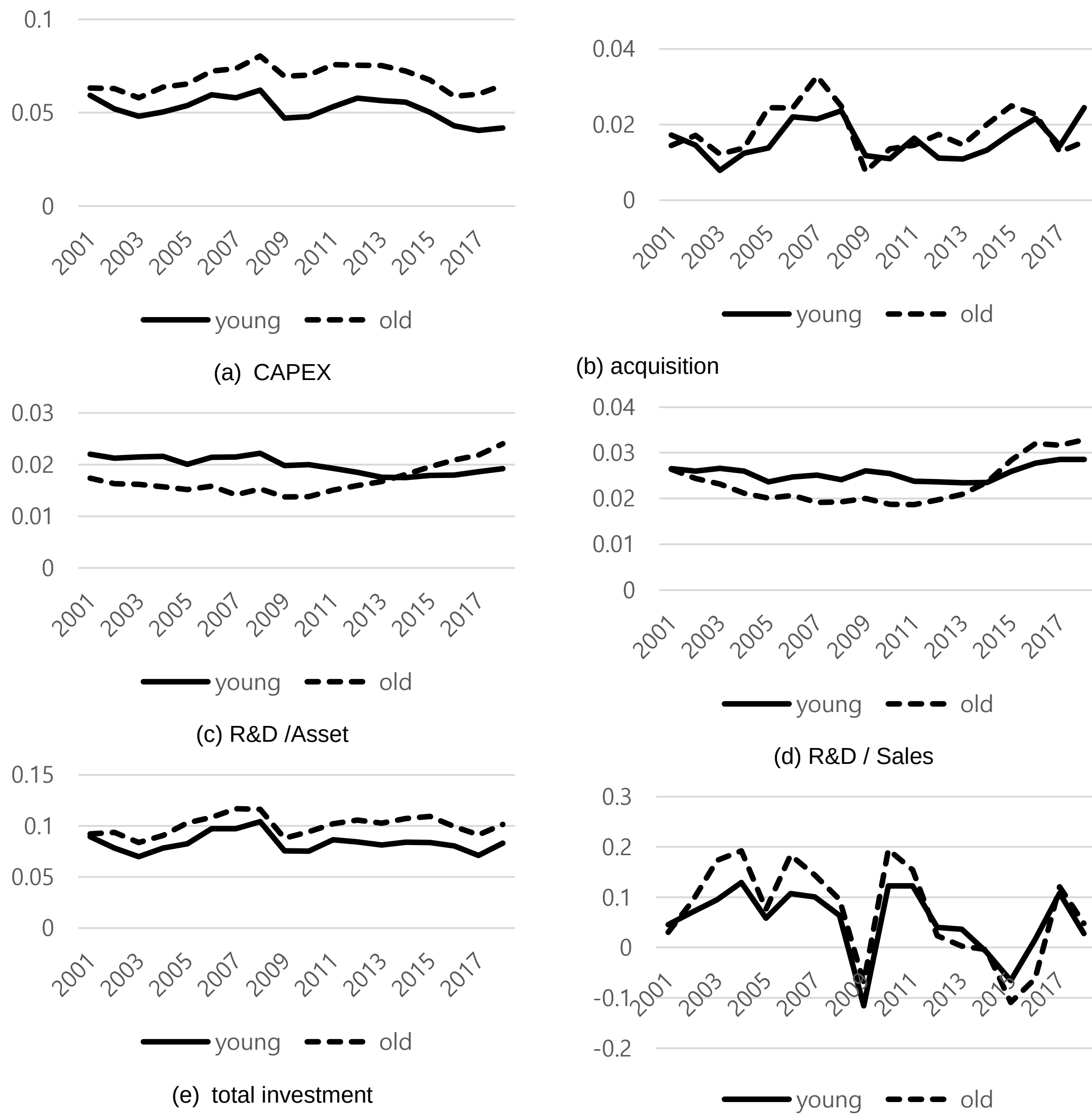
$$Distress\ or\ EXIT_{i,t} = \beta_0 + \beta_1 Age + \beta_2 R\&D + \beta_3 Age \cdot R\&D + \beta_4 Age \cdot post + \beta_5 R\&D \cdot post + \beta_6 R\&D \cdot age \cdot post + \delta_1 \cdot controls_{i,t-1} + \alpha_t + \gamma_i + \varepsilon_{i,t} \quad (3)$$

The dependent variable in the specification is binary variable equal to 1 when a firm faces financial distress or zero otherwise. For the survival possibility, we also use exit as a dependent variable. Following Hill, Kelly and Highfield (2010) and Aktas, Croci and Petmezas (2015), a firm is financially distressed if two criteria is met: (1) the firm faces difficulty to cover its interest expenses if its interest coverage ratio (i.e., operating income before depreciation divided by interest expense) is below one for two consecutive years or less than 0.80 in any given year; (2) The firm is considered to be overleveraged if it is in the top two deciles of industry leverage in a given year. Based on De and Nagaraj (2014) and Bøler, Moxnes and Ulltveit-Moe (2015), another dependent variable is the binary variable EXIT that equals one if the firm is present in time t but not in t+1. Post are indicator variables equal to one for fiscal quarters with an end-date from the third quarter of 2009 to the second quarter of 2016, respectively. γ_i is firm fixed effects, and α_t represents a set of fiscal and calendar-quarter dummies to control for seasonality. Following Altman, Iwanicz-Drozdowska, Laitinen & Suvas (2014), control variables include leverage, WCTA (=working capital / total assets), RETA (=retained earnings / total assets), EBITTA (=EBIT / total assets), BVETD (=book value of equity/total liabilities), size and size squared.

In equation (3), β_1 and β_2 measure the effects of firm age and R&D investment on the likelihood of a firm's facing financial distress or facing an exit threat, respectively. Coefficient of interaction term between Age and R&D, β_3, measures additional effects of firm age at a given level of R&D. β_4, β_5 and β_6 measure how those effects change during the post crisis period, respectively. Other than R&D investment, we also apply CAPEX, acquisition and total investment to check if those investment yield higher respective risks based on firm age.

Data Presentation and Analysis

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 R&D to total assets, as well as R&D expense-to-sales, acquisition to total assets (Acquisition), capital expenditure to total asset (CAPEX), and ratio of the sum of R&D expenses, and acquisition plus capital expenditure minus sale of property, plant and equipment over total assets (Total Investment). CAPEX-to-asset ratio and total investment rate are higher for old firms during our sample period. Acquisition and sales growth exhibit somewhat mixed trend in that old firms hold higher rates for certain periods: old firms hold higher acquisition except for 2001, 2009, 2011 and 2017-2018. With respect to sales growth, old firms show higher growth rate except for 2001, 2012-2013, and 2015-2016. Our main measure of innovation, R&D to asset as well as R&D to sales show interesting trend in that old firm starts to transcend young companies' rate in 2014. It implies that old firm can put innovation effort more than young competitors, and we believe that it is worth analyzing whether this result is statistically valid.



(a) CAPEX

(b) acquisition

(c) R&D /Asset

(d) R&D / Sales

(e) total investment

(f) Sales growth

Old vs young firms

Figure 1: CAPEX, acquisition, R&D-to-asset, R&D-to-sales, total investment, and sales growth 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 age. Following Richardson(2006), total investment is the sum of capital expenditure, acquisitions and R&D minus sale of property, plant and equipment. Data come from compustat database

Table 2 provides summary statistics for our data. The average investment ratio, R&D, acquisition and total investment for the entire sample period are 0.031, 0.021, 0.010 and 0.070, respectively. The median investment, R&D, acquisition and total investment ratio are 0.013, zero, zero and 0.035. Last three columns show the subgroup means and whether each subgroup mean is statistically different from each other when firms are grouped based on firm age. Except for ROA, debt issuance, retained earnings to total asset (RETA henceforth), sale of PP&E (sPPE), and PP&E (PPEA), the average young firm variables are significantly different from old counterpart.

Table 2: Summary Statistics

	N	Mean	Median	Std. Dev.	Min	Max	Firm age		
							Old (n=196,507)	Young	t-stat
ROA	365,190	-0.1678	0.0018	0.7732	-6.3009	0.1729	-0.2523	-1.7577	1.30
Q	368,367	0.6524	0.6339	0.1623	0.23	1	0.6466	0.6533	-8.51
NWC	365,190	-0.6161	-0.0012	3.6228	-30.75	0.52	-0.4532	-0.6417	10.76
size	365,185	4.9681	5.2043	2.9809	-3.91	11.10	6.2024	4.7747	100.42
Intangible	365,190	0.1394	0.0318	0.2001	0.00	0.81	0.1846	0.1324	54.22
Debt Issue	365,190	0.0159	0.00	0.1046	-0.23	0.68	0.0138	0.0163	-4.86
WCTA	365,190	-0.3875	0.1767	3.5981	-30.27	0.92	-0.2559	-0.4081	8.75
RETA	365,190	-8.0841	-0.0602	39.931	-341.12	0.88	-8.1227	-8.0781	-0.23
BVETB	365,585	0.9492	0.00	2.7337	-0.96	19.47	1.8192	0.8131	76.82
CAPEX	365,190	0.0310	0.0135	0.0497	0	0.31	0.0259	0.0318	-24.57
Acquisition	365,190	0.0107	0.00	0.0392	-0.002	0.27	0.0115	0.0107	4.09
Total Investment	365,190	0.0705	0.0355	0.1068	-0.01	0.68	0.0583	0.0725	-27.43
leverage	365,190	1.2572	0.5165	4.1550	0.02	35.40	1.1255	1.2779	-7.59
age	401,358	26.59	19.00	20.3410	0	56	34.547	25.438	95.59
RD	365,190	0.0217	0.00	0.0577	0	0.41	0.0163	0.0226	-22.54
Cash Flow Risk	369,857	0.2598	0.0175	1.2818	0	10.77	0.1315	0.2803	-24.31
Fixed Asset	350,537	3.1985	3.4062	3.3402	-5.30	10.03	4.4039	3.0070	86.07
Cash	365.190	0.2260	0.1163	0.2594	0	0.99	0.1962	0.2308	-27.56
Sale of PPE	365,190	-0.0012	0.00	0.0081	-0.06	0.02	-0.0012	-0.0012	-0.79
PPEA	365,190	0.2465	0.1552	0.2462	0	0.93	0.2427	0.2471	-3.67
Equity issue	342,431	0.1095	0.0019	0.8468	-2.55	6.27	0.0172	0.1248	-25.95
Sales volatility	332,413	0.3544	0.1678	0.5244	0.02	3.14	0.2295	0.3753	-56.35
Sales growth	336,837	0.0075	0.0193	0.4115	-1.88	1.70	-0.0013	0.0090	-5.06
Cash Flow	365,190	-0.0951	0.0164	0.5250	-4.25	0.15	-0.0396	-0.1038	25.30

This table presents summary statistics of the main variables used in the analysis for the quarterly data from 2000Q3 to 2016Q2. We calculate means, medians, and standard deviations, minimum and maximum over the entire sample period. Following Duchin et al. (2010). We classify firms by dividing the sample at the median each quarter using firm age. Data comes from Compustat database.

Next, we discuss our findings and robustness tests: Firstly, Table 3 shows whether young firms invest more in innovative activities than old firms over the sample period. Interaction terms with post dummies indicate how the effects have changed after the crisis. In fact, negative and significant coefficients for firm age change to positive after the crisis, meaning that old firms spend corporate resources significantly more young counterparts.

The age and CF interaction term suggests that during the post-crisis period, old firms increase their spending on R&D and total investment at a given level of cash flow. Conversely, young firms invest more in acquisition in the post-crisis period, controlling for financial constraint. Consistent with Shrader, Monllor and Shelton (2009), it is evidenced that young firms may pursue aggressive growth through acquisition of their competitor. Based on R&D result, the innovation of old firms is higher than those of the young firms.

Table 3: Firm Age and Investment before and after the financial crisis				
	CAPEX	R&D	Acquisitions	Total investment
Q	0.0180***	0.0470***	0.0016**	0.0683***
	(0.0007)	(0.0007)	(0.0006)	(0.0016)
CF	-0.0043***	-0.0321***	-0.0006	-0.0492***
	(0.0005)	(0.0006)	(0.0005)	(0.0013)
Cash	0.0056***	0.0220***	-0.0200***	0.0113***
	(0.0007)	(0.0007)	(0.0006)	(0.0016)
SG	0.0005**	0.0002	0.0014***	0.0028***
	(0.0002)	(0.0002)	(0.0002)	(0.0005)
lagGDP	-0.0006***	0.0004***	-0.0001***	-0.0003
	(0.0006)	(0.0007)	(0.0006)	(0.0001)
salePPE	-0.1366***	0.0551***	-0.0680***	-3.0042***
	(0.0141)	(0.0153)	(0.0134)	(0.0321)
PPEA	0.1101***	0.0142***	-0.0141***	0.1315***
	(0.0008)	(0.0009)	(0.0008)	(0.0019)
leverage	-0.0012***	-0.0012***	0.0001**	-0.0023***
	(0.0005)	(0.0006)	(0.0005)	(0.0001)
size	-0.0010***	-0.0024***	0.0030***	-0.0011***
	(0.0007)	(0.0008)	(0.0007)	(0.0001)
Equityissue	0.0001	-0.0012***	0.0012***	0.0003
	(0.0001)	(0.0001)	(0.0001)	(0.0003)
Debtissue	0.0514***	0.0169***	0.0816***	0.2123***
	(0.0012)	(0.0013)	(0.0012)	(0.0028)
Age	-0.0004***	-0.0006***	0.0001***	-0.0011***
	(0.0004)	(0.0004)	(0.0004)	(0.0009)
CF*age	0.0001	0.0002***	0.0008	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0003)
Interaction with POST-crisis dummy				
Q	-0.0026***	0.0093***	-0.0014*	0.0123***
	(0.0008)	(0.0009)	(0.0008)	(0.0019)
CF	0.0022***	-0.0332***	0.0017**	-0.0496***
	(0.0008)	(0.0009)	(0.0007)	(0.0018)
Cash	-0.0115***	-0.0014	0.0007	-0.0198***
	(0.0008)	(0.0009)	(0.0008)	(0.0019)
SG	-0.0004	0.0012***	0.0010***	0.0020**
	(0.0003)	(0.0004)	(0.0003)	(0.0008)
lagGDP	0.0007***	-0.0005***	0.0001**	0.0005
	(0.0008)	(0.0009)	(0.0007)	(0.0001)
salePPE	-0.0707***	-0.0269	0.0335*	0.2310***
	(0.0207)	(0.0225)	(0.0197)	(0.0471)
PPEA	-0.0195***	0.0002	-0.0066***	-0.0337***
	(0.0008)	(0.0009)	(0.0008)	(0.0019)
leverage	0.0006***	-0.0003***	-0.0001***	-0.0004***
	(0.0006)	(0.0007)	(0.0006)	(0.0001)
Size	0.0006***	0.0002***	-0.0006***	0.0005***
	(0.0007)	(0.0007)	(0.0006)	(0.0001)
Equityissue	-0.0001	0.0001	0.0021***	0.0027***
	(0.0001)	(0.0002)	(0.0001)	(0.0004)
debtissue	-0.0176***	-0.0012	0.0136***	-0.0161***
	(0.0016)	(0.0018)	(0.0016)	(0.0038)
Age	0.0007***	0.0003***	0.0001*	0.0001***
	(0.0001)	(0.0001)	(0.0009)	(0.0002)
CF*age	-0.0002	0.0005***	-0.0004**	0.0007***
	(0.0002)	(0.0002)	(0.0001)	(0.0004)
R square	0.56	0.61	0.27	0.52
N obs	215,798	215,798	215,798	215,798

This table (Table 3) reports the effect of firm age and innovation on investment. Dependent variables are CAPEX, acquisition, R&D and total investment in year t, covering 2001Q3 to 2016Q2. The independent variables include NWC, size, intangible assets, leverage, risk, fixed asset growth, cash, sales volatility, cash flow, financial distress and sales growth. Post is indicator variable equal to one for fiscal quarters with an end-date from the third quarter of 2009 to the second quarter of 2015. Variable definitions are provided in table 8. Standard errors are in parentheses which are robust and clustered at firm level, following Aktas et al. (2015). Data come from Compustat database.

In table 4, we report the effect of R&D on profitability and firm value, depending on firm age. Firstly, the age coefficient tells us that old firm enjoys higher profitability and firm value over the entire sample period. However, at the given level of R&D, young innovative firm, defined as firms doing R&D investment, gets higher profitability. Market value for young innovative firms is greater than old competitors, and it gets stronger in the post-crisis period.

Along with R&D, we also investigate the effect of other investments on profitability and firm value: acquisition effect is insignificant. The result from CAPEX interacted with age, on the other hand, supports both young innovative firm profitability and market value well in the post-crisis. Lastly, total investment effect on profitability turns into significantly negative at 10% significance level, and the negative effect on Tobin's Q gets stronger in the post-crisis period. To sum up, old firms may spend more in R&D, but young innovative firms enjoy higher profitability and market value than old competitors especially in the post-crisis period. Moreover, the effect of young firm innovation on market value is pretty consistent.

Table 4: The Effects of R&D and Firm Age on Performance and Market Value

X:	X: R&D		X: acquisitions		X: CAPEX		X: total	
Variable	ROA	Tobin's Q	ROA	Tobin's Q	ROA	Tobin's Q	ROA	Tobin'sQ
NWC	-0.0062***	0.0167***	-0.0085***	0.0185***	-0.0077***	0.0176***	-0.0068***	0.0171***
	(0.0017)	(0.0007)	(0.0017)	(0.0007)	(0.0017)	(0.0007)	(0.0017)	(0.0007)
Size	0.0196***	0.0738***	0.0175***	0.0760***	0.0173***	0.0762***	0.0189***	0.0744***
	(0.0012)	(0.0004)	(0.0012)	(0.0005)	(0.0012)	(0.0004)	(0.0012)	(0.0004)
Intangible assets	-0.0241***	0.0186***	-0.0238**	0.0170***	-0.0344***	0.0324***	-0.0249***	0.0192***
	(0.0092)	(0.0037)	(0.0093)	(0.0038)	(0.0093)	(0.0038)	(0.0093)	(0.0037)
Leverage	-0.0528***	0.0274***	-0.0543***	0.0286***	-0.0537***	0.0282***	-0.0530***	0.0277***
	(0.0015)	(0.0006)	(0.0015)	(0.0006)	(0.0015)	(0.0006)	(0.0015)	(0.0006)
Age	0.0020***	0.0042***	0.0018***	0.0042***	0.0014***	0.0044***	0.0016***	0.0043***
	(0.0004)	(0.0001)	(0.0004)	(0.0001)	(0.0004)	(0.0001)	(0.0004)	(0.0001)
X	-0.6143***	0.6356***	-0.1936***	0.1529***	-0.4771***	0.6243***	-0.2758***	0.2817***
	(0.0384)	(0.0155)	(0.0483)	(0.0199)	(0.0367)	(0.0149)	(0.0171)	(0.0069)
Risk	0.0012	0.0159***	0.0022	0.0153***	0.0025	0.0150***	0.0025	0.0150***
	(0.0018)	(0.0007)	(0.0018)	(0.0007)	(0.0018)	(0.0007)	(0.0018)	(0.0007)
Fixed Asset growth	-0.0125***	-0.0197***	-0.0099***	-0.0223***	-0.0073***	-0.0262***	-0.0092***	-0.0229***
	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0012)	(0.0005)
Cash	-0.0501***	0.2406***	-0.0764***	0.2577***	-0.0733***	0.2550***	-0.0661***	0.2515***
	(0.0070)	(0.0028)	(0.0070)	(0.0028)	(0.0069)	(0.0028)	(0.0070)	(0.0028)
Sales volatility	-0.0074***	0.0004	-0.0080***	0.0006	-0.0076***	0.0005	-0.0072***	0.0002
	(0.0021)	(0.0008)	(0.0021)	(0.0008)	(0.0021)	(0.0008)	(0.0021)	(0.0008)
CF	0.9960***	-0.0412***	1.0195***	-0.0589***	1.0158***	-0.0540***	1.0055***	-0.0458***
	(0.0038)	(0.0015)	(0.0037)	(0.0015)	(0.0037)	(0.0015)	(0.0038)	(0.0015)
Financial distress	0.0035	-0.0243***	0.0025	-0.0241***	0.0035	-0.0243***	0.0030	-0.0237***
	(0.0031)	(0.0012)	(0.0031)	(0.0013)	(0.0031)	(0.0012)	(0.0031)	(0.0012)
Sales growth	0.0158***	0.0090***	0.0157***	0.0089***	0.0160***	0.0084***	0.0167***	0.0081***
	(0.0025)	(0.0010)	(0.0025)	(0.0010)	(0.0025)	(0.0010)	(0.0025)	(0.0010)
X*age	-0.0062***	-0.0012**	0.0022	-0.0021***	0.0033***	-0.0028***	0.0002	-0.0009***
	(0.0013)	(0.0005)	(0.0017)	(0.0007)	(0.0012)	(0.0005)	(0.0005)	(0.0002)
NWC*post	0.0025**	0.0104***	0.0016	0.0130***	0.0016	0.0126***	0.0021*	0.0114***
	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0012)	(0.0005)
Size*post	0.0040***	0.0656***	0.0024**	0.0699***	0.0031***	0.0682***	0.0037***	0.0668***
	(0.0010)	(0.0004	(0.0010)	(0.0004)	(0.0010)	(0.0004)	(0.0010)	(0.0004)
Intangible assets*post	0.0048	0.0341***	0.0069	0.0340***	0.0015	0.0422***	0.0089	0.0250***
	(0.0079)	(0.0032)	(0.0081)	(0.0033)	(0.0080)	(0.0032)	(0.0080)	(0.0032)
Leverage*post	-0.0333***	0.0189***	-0.0336***	0.0203***	-0.0337***	0.0201***	-0.0334***	0.0194***
	(0.0010)	(0.0004)	(0.0010)	(0.0004)	(0.0010)	(0.0004)	(0.0010)	(0.0004)
Age*post	0.0021***	0.0036***	0.0020***	0.0034***	0.0018***	0.0037***	0.0018***	0.0036***
	(0.0003)	(0.0001)	(0.0003)	(0.0001)	(0.0003)	(0.0001)	(0.0003)	(0.0001)
X*post	-0.2687***	0.9832***	0.0234	-0.0145	-0.1298***	0.7608***	-0.1146***	0.4173***
	(0.0358)	(0.0145)	(0.0524)	(0.0215)	(0.0486)	(0.0198)	(0.0186)	(0.0075)
Risk*post	-0.0025**	0.0120***	-0.0019	0.0105***	-0.0015	0.0101***	-0.0020	0.0111***
	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0012)	(0.0005)
Fixed asset growth*post	-0.0023**	-0.0189***	-0.0008	-0.0231***	-0.0001	-0.0249***	-0.0012	-0.0223***
	(0.0010)	(0.0004)	(0.0010)	(0.0004)	(0.0010)	(0.0004)	(0.0010)	(0.0004)
Cash*post	-0.0344***	0.2219***	-0.0378***	0.2493***	-0.0443***	0.2557***	-0.0407***	0.2419***
	(0.0063)	(0.0025)	(0.0062)	(0.0025)	(0.0063)	(0.0025)	(0.0063)	(0.0025)
Sales volatility*post	-0.0085***	0.0043***	-0.0077***	0.0042***	-0.0076***	0.0039***	-0.0080***	0.0039***
	(0.0026)	(0.0010)	(0.0026)	(0.0011)	(0.0026)	(0.0010)	(0.0026)	(0.0010)
CF*post	1.0564***	-0.0390***	1.0686***	-0.0653***	1.0662***	-0.0618***	1.0596***	-0.0482***
	(0.0031)	(0.0012)	(0.0030)	(0.0012)	(0.0030)	(0.0012)	(0.0031)	(0.0012)
Financial distress*post	0.0143***	-0.0007	0.0150***	-0.0008	0.0136***	0.0008	0.0137***	-0.0004
	(0.0029)	(0.0012)	(0.0029)	(0.0012)	(0.0029)	(0.0012)	(0.0029)	(0.0012)
Sales growth*post	0.0083***	0.0072***	0.0077***	0.0087***	0.0074***	0.0084***	0.0081***	0.0068***
	(0.0026)	(0.0010)	(0.0026)	(0.0011)	(0.0026)	(0.0010)	(0.0026)	(0.0010)
X*age*post	-0.0022**	-0.0093***	-0.0012	-0.0009	-0.0055***	-0.0072***	-0.0008*	-0.0049***
	(0.0009)	(0.0003)	(0.0014)	(0.0005)	(0.0011)	(0.0004)	(0.0004)	(0.0001)
R	0.82	0.76	0.82	0.75	0.82	0.76	0.82	0.76
N	215,798	215,798	215,798	215,798	215,798	215,798	215,798	215,798

This table (Table 4) reports firm age and innovation effect on profitability and market value. The dependent variable is ROA, from 2000Q3 to 2016Q2. X refers to four types of investment in the first row to see whether firms doing investment X yield higher ROA or Tobin's Q. The other dependent variable is Tobin's Q. Post is indicator variable equal to one for fiscal quarters from 2009Q3 to 2016Q2. Firm-level control variables include NWC, size, intangibles, leverage, cash flow risk, fixed asset growth, cash, sales volatility, cash flow, financial distress, and sales growth. Standard errors in parentheses are robust to clustering by firm and quarter. All equations include quarterly time dummies and firm dummies. Variable definitions are in table 1. Data come from Compustat database.

Table 5 summarizes the results on whether innovation exposes firms to financial distress risks or survival (or market exit) risks and whether such relation varies over firm age. Firms with R&D activities are more likely to face financial distress risks before and after the 2008 crisis; Firms doing R&D are more likely to have firm exit risks before the crisis, but less likely to have those risks after the crisis. The negative coefficient of the interaction term between R&D and Age persists in the post-crisis period, and it shows that among firms with R&D activities, older firms face a lower probability of financial distress. The post-crisis coefficient of R&D and age is due to the fact that firms with specialized products are vulnerable to financial distress, so young firms, in particular, that engage in R&D may suffer more in economically distressed periods (Opler and Titman, 1994). Except for CAPEX under column A, given the level of innovation effort, a mature firm faces lower possibility of financial distress. However, market exit after the crisis changes to positive, implying that old innovative firms expose themselves to higher survival risks, while young innovative firms hold higher market exit risks before the crisis. Compared to financial distress risks, column B shows stronger result in that old innovative firms, defined as firms with R&Ds as well as other investments, hold higher survival risks than young competitors. In sum, it becomes evident that poor performance and market value actually increase failure of old firms during the post-crisis period.

Table 5: Investment and Financial Distress of Firms in 2001-2015

dependent	Financial Distress Dummy (column A)				Firm Exit Dummy (Column B)			
Variable	R&D	ACQ	CAPX	TOTALI	R&D	ACQ	CAPEX	TOTALI
Age	-0.0053***	-0.0075***	-0.0070***	-0.0068***	0.0061***	0.0060***	0.0072***	0.0069***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
X	13.8168***	-1.4947***	-1.2588***	0.2354***	0.8895***	0.5150***	1.9087***	0.7259***
	(0.4163)	(0.1808)	(0.1369)	(0.0788)	(0.1252)	(0.1732)	(0.1260)	(0.0615)
X*age	-0.1445***	0.0030	-0.0144***	-0.0109***	-0.0365***	-0.0290***	-0.0597***	-0.0243***
	(0.0151)	(0.0066)	(0.0047)	(0.0027)	(0.0043)	(0.0062)	(0.0042)	(0.0020)
Debt ratio	0.0137	-0.0268**	-0.0328***	-0.0235**	0.0658***	0.0698***	0.0666***	0.0642***
	(0.0117)	(0.0107)	(0.0106)	(0.0108)	(0.0068)	(0.0069)	(0.0069)	(0.0067)
WCTA	-0.0107***	0.0835***	0.0735***	0.0887***	0.0443***	0.0485***	0.0463***	0.0432***
	(0.0013)	(0.0121)	(0.0120)	(0.0122)	(0.0077)	(0.0078)	(0.0077)	(0.0076)
RETA	-4.1942***	-0.0185***	-0.0184***	-0.0186***	-0.0022***	-0.0023***	-0.0022***	-0.0021***
	(0.0882)	(0.0017)	(0.0017)	(0.0017)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
EBITTA	0.0673***	-4.6205***	-4.6497***	-4.6226***	-0.1835***	-0.1928***	-0.1760***	-0.1708***
	(0.0071)	(0.0835)	(0.0832)	(0.0837)	(0.0120)	(0.0114)	(0.0115)	(0.0118)
BVETD	-0.2953***	0.0610***	0.0721***	0.0621***	-0.0563***	-0.0562***	-0.0557***	-0.0559***
	(0.0051)	(0.0070)	(0.0073)	(0.0070)	(0.0047)	(0.0047)	(0.0047)	(0.0047)
Size	0.0122***	-0.2626***	-0.2544***	-0.2702***	0.2204***	0.2277***	0.2153***	0.2145***
	(0.0005)	(0.0051)	(0.0052)	(0.0053)	(0.0038)	(0.0038)	(0.0039)	(0.0039)
Size squared	0.0122***	0.0086***	0.0079***	0.0091***	-0.0285***	-0.0291***	-0..0283***	-0.0281***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Interaction with post-crisis dummy								
Age*post	-0.0010***	-0.0025***	-0.0029***	-0.0022***	-0.0064***	-0.0059***	-0.0063***	-0.0066***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
X*post	8.5916***	-1.0464***	-1.6654***	0.3396***	-2.0598***	-0.0819	-1.1530***	-0.9897***
	(0.3646)	(0.2164)	(0.1856)	(0.0974)	(0.1230)	(0.1950)	(0.1624)	(0.0688)
X*age*post	-0.0740***	-0.0144**	0.0182***	-0.0057**	0.0326***	0.0099*	0.0321***	0.0193***
	(0.0102)	(0.0061)	(0.0047)	(0.0025)	(0.0030)	(0.0054)	(0.0039)	(0.0016)
Debt ratio	0.0304***	0.0872***	0.0864***	0.0936***	-0.0158***	-0.0221***	-0.0203***	-0.0180***
	(0.0110)	(0.0118)	(0.0118)	(0.0119)	(0.0040)	(0.0041)	(0.0041)	(0.0040)
WCTA	0.0419***	0.1219***	0.1185***	0.1295***	-0.0201***	-0.0280***	-0.2068***	-0.0239***
	(0.0122)	(0.0128)	(0.0128)	(0.0129)	(0.0045)	(0.0046)	(0.0046)	(0.0045)
RETA	-0.0014**	-0.0054***	-0.0055***	-0.0052***	0.0003*	0.0005***	0.0005***	0.0003**
	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
EBITTA	-4.7741***	-5.1371***	-5.1618***	-5.1288***	0.0375***	0.0822***	0.0797***	0.0553***
	(0.0955)	(0.0904)	(0.0902)	(0.0909)	(0.0097)	(0.0092)	(0.0092)	(0.0095)
BVETD	0.1345***	0.1382***	0.1390***	0.1392***	-0.0140***	-0.0142***	-0.0141***	-0.0141***
	(0.0022)	(0.0022)	(0.0022)	(0.0022)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Size	-0.4080***	-0.3971***	-0.3928***	-0.4066***	0.0206***	0.0097***	0.0168***	0.0232***
	(0.0050)	(0.0052)	(0.0052)	(0.0053)	(0.0032)	(0.0032)	(0.0032)	(0.0033)
Size squared	0.0157***	0.0143***	0.0140***	0.0149***	-0.0105***	-0.0093***	-0.0097***	-0.0103***
	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R square	87.3	86.8	86.8	86.8	72.7	72.6	72.6	72.7
N. Obs	215,798	215,798	215,798	215,798	215,798	215,798	215,798	215,798

The table (Table 5) is a probit regression result with binary dependent variable equal to 1 for firms that experience financial distress or market exit covering 2000Q3 to 2016Q2. The dependent variable is binary equal to 1 when a firm faces financial distress or zero otherwise. Following Hill et al. (2010) and Aktas et al. (2015), a firm is financially distressed if two criteria is met: (1) the firm faces difficulty to cover its interest expenses if its interest coverage ratio is below one for two consecutive years or less than 0.80 in any given year; (2) The firm is considered to be overleveraged if it is in the top two deciles of industry leverage in a given year. Based on De and Nagaraj (2014) and Boler et al. (2015), another dependent variable is the binary variable EXIT that equals one if the firm is present in time t but not in t+1. X refers to four types of investment in the second row to see whether firms have higher investment X. Post is indicator variable equal to one for fiscal quarters with an end-date from the third quarter of 2009 to the second quarter of 2015..Firm-level control variables include leverage, WCTA(working capital to total asset), RETA(retained earnings to total asset), EBITTA(earnings before interest and text to total asset), BVETD(book value of equity to total liabilities), size and size squared, following Altman et al.(2014). Standard errors are in parentheses robust to clustering by firm and quarter. All equations include quarterly time dummies and firm dummies. Variable definitions are in table 1. Data come from Compustat database.

As robustness tests, we apply two other firm age classifications: following Duchin et al (2010), we classify firms as old and young by dividing the sample at the median firm age in each quarter; we classify the sample as young firms when they are less than 5 years after IPO (Covin et al., 1990; Zahra, 1996). Following Cloodt et al. (2006), we use subsample of firms in high-tech industries that include 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). The same result applies to highly innovative industries where old firm holds higher R&D investment both in pre- and post-crisis period. Overall, our results are mainly consistent in that young innovative firms, defined as firms doing R&D investment, invest less than old competitors but holds higher profitability and market value after the crisis. They have lower exit risk, but financial distress risk gets higher after the 2008 crisis. Due to space limitations, untabulated results are available from the authors upon the request.

Conclusion and Recommendations

This study empirically tests the profitability and stock market value of innovative activities such as R&D investment, capital expenses, acquisitions and total investment considering firm age, using US non-financial publicly listed firms 2000 and 2016. We found that old innovative firms, defined as firms with R&D investment, have higher exit risk in the post-crisis period than young counterpart. Old firms, at the given level of CAPEX, R&D, acquisition and total investment, hold higher survival risk after the 2008 crisis while for financial distress risk, young firms hold higher financial distress risk when they carryout R&D activity in the post-crisis period. This could cause a potential downside for young firm innovation.

We conclude that old firms should invest more on innovative activities than young competitors. In controlling a firm's financial constraint, old firms significantly spend more on R&D and total investment. Moreover, after the 2008 crisis, old firms continue to significantly invest more in those investments than young competitors do. However, the effects of R&D on profitability are larger in young innovative firms though old firms in high-tech industries are more profitable. This study finding on R&D strongly supports our hypothesis which states that old firm investment does not guarantee higher profitability than young counterparts after the 2008 crisis. The effects of R&D on Tobin's Q suggest that expenditure on R&D by young firms are valued higher than old counterpart: Tobin's Q is larger in young innovative firms throughout the period we investigated, more so in the post-crisis period, where the valuation of young firm innovation gets even stronger.

Our study contributes to studies on the relation between firm age and firm performance (Jovanovic, 1982; Ericson and Pakes, 1995, Coad et al., 2013). First, this paper quantifies investors' valuation for R&D activities rather than researchers' subjective valuation by employing firm value. Secondly, analyzing publicly-traded firms that survived early financing difficulties, our estimation avoids issues related to financing problems of small start-ups or venture firms in R&D activities. Finally, our paper examines how R&D and other investment activities of young firms affect profitability and the value of US firms using the data after the dot-com bubble burst including the post-crisis period. Especially, our result reconciles the controversy of whether there is adverse relation between firm age and innovation, since mature firm may be capable of research capacity, it may take some time to get benefits from their innovation effort. When there is a shock in the economy, market may observe innovative firms facing survival risks, so it devalues those firms even more after the crisis. As our results suggest that young firms play an important role in innovation after the aggregate shock in the economy, thus, there is a need to modify the details of the corporate life cycle hypothesis.

The moderating effects of firm age on the relation between corporate innovation and firm performance along with firm risks provide some implications on corporate innovative activities. One, our study suggests that innovation activities of old firms do not improve firm value more than those of young firms after the financial crisis. Even with innovation efforts, old firms find it hard to grow substantially once the business is mature. Realizing such problems while going through a massive negative shock in the economy, investors appreciate the growth option value of old firms less than before. Two, old firms face a high probability of market exit after the 2008 crisis. Three, our study can provide a clue why recent M&As took up from 1.03% in 2009 to 2.20% in 2018. Better profitability and market value for young innovative firms might have induced their incentive to take market share from competitors. Four, even if young firms are highly valued in the post-crisis period, those firms are still exposed to financial distress risk, and this is evident in very young firms.

While our study suggests the weaker role of old firms in innovative activities after the crisis, it is based on relatively short time period covering 2000 to 2016 after the dot com bubble burst. Our results might stem from the paucity of dramatic innovation and technological changes during our sample periods. With dramatic innovation and technological changes in the future, mature innovative firms might enjoy higher profitability and investors might evaluate their activities more optimistically.

In summary, old innovative firms face difficulty in external funding during macro-economic crisis more than young firms. The effects of R&D investment on firm value in the stock market are smaller in old firms than young ones, suggesting that investors help to lower the value of growth option for old innovative firms. In contrast to the conventional belief, our findings suggest that there would be weakness for old firm innovation after the 2008 crisis, despite the fact that they hold higher investment efforts than young ones.

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