R&D Expenditure and Firm Performance in China

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Abstract

This study investigates the relationship between firm profits, R&D expenditure, firm size and financial leverage in China over the period 2009-2015. The starting point of this paper is to estimate how R&D inputs affect firm future performance. We consider two different regression models to verify the hypotheses from the empirical literature.

Our first approach is to apply panel data regression models estimating the individual specific effects within 11 industries. The second approach is to evaluate interaction effects between R&D expenditure, firm size, and leverage. Then we test whether individual heterogeneity is correlated with other independent variables. Our last approach is to estimate VAR models and confirm the dynamic relationship between the variables at the first-order lag. We also determine whether moderating variables change the strength of the relationship between R&D expenditure and profits. Specifically, moderating effects of employees' education level, firm size, and leverage are herein analyzed, together with a discussion of Granger causality.

We find that the effect of the first-lag of R&D expenditure on profits is positive from the results of panel data regression model. Compared with the first and second lag of R&D expenditure, the third-lag of R&D expenditure has a greater positive effect on profits. In addition, the interaction variables of R&D and other two factors have different effects on firm profits. We suggest that the moderating variables change the relationship between the variables of the VAR model. We also support idea that Granger causality exists in some pairs of the first-lags between R&D expenditure, firm profits, firm size and leverage.

Keywords: R&D Expenditure, Firm Performance, Panel Data, VAR Model, Granger Causality

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1. Introduction

R&D programs developed rapidly over the past decade in China (Walsh, 2007). In 2016, China became the second biggest investor in R&D in the world, with an expenditure of $396.3 billion (Industrial Research Institute, 2016). In fact, Chinese companies are seeking more opportunities to invest R&D in the process of product upgrading and product innovation. Chinese companies build their innovation culture and approaches (Dehn, 2015).

However, the process of R&D is a fundamentally uncertain activity (Amoroso, 2015). The starting point is to estimate how R&D behavior affects the performance of Chinese firms. For this reason, we estimate R&D expenditure, firm size and financial leverage as the control variables and study the dynamic relationship between the three control variables and firm performance with the use of panel data regression and VAR models. Following the literature (Hou and Li, 2010), we choose R&D expenditure, firm size, and leverage as control variables. We use operating profit as a measure of firm performance (Hax, 2003). A firm's profit is affected by R&D expenditure, firm size, and financial leverage predominantly (Yuan and Ming, 2011). However, many studies show that efforts from R&D investment have lagged behind effects on profits (Hsu et al., 2013). Rouvinen (2002) applied dynamic panel regression models and Granger's causality test, respectively, to verify whether R&D activities improve total-factor productivity. We also consider the moderating effects of firm size, leverage, and workforce education level on the relationship between R&D and firm performance. Finally, we verify the causality between variables using Granger's causality test.

We apply panel data regression models to support that firm performance is affected by past R&D expenditure with first-order lag. The regression results support that firm size has a positive effect on firm performance, while leverage has an adverse effect. Moreover, the interaction effects of them and R&D activity respectively reflect the substitutive and the complementary relationship in terms of affecting performance. Under specified conditions, the results of the VAR models support that Granger causality exists in R&D behavior, firm performance, firm size, and leverage.

This paper is organized into seven sections. In Section 2, we review the different viewpoints and methods from the literature and conclude that R&D expenditure has positive effects on firm performance as shown in previous studies. Some empirical evidence shows that the lagged value of R&D also has a positive effect on firm performance. Besides firm size, leverage and the education level of the workforce are also related to firm performance. In Section 3, we list the hypotheses that are based on previous studies and supported by the results. We present the variables and data in Section 4 and illustrate the methods and models in Section 5. Section 6 presents the analysis of panel data regression and VAR results. We estimate and analyze the relationships between the first-order, second-order, and third-order lags of R&D expenditure and firm performance respectively. We choose the most efficient and consistent model from the fixed or random effects model using Hausman test. In the second part of section 6, we apply Fisher's unit root test to confirm the feasibility of VAR models and Granger causality. We consider four variables in VAR models, which are R&D expenditure, firm performance, firm size, and leverage. Each VAR model includes moderating dummy variables that affect the form or the strength of the relationship between the four variables (Le et al., 2005).

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2. Literature Review

2.1. R&D and Firm Performance

A number of studies have analyzed the relationship between R&D and firm performance. Some studies found a positive effect of R&D on performance (Branch, 1974; Cohen and Levinthal, 1989; Freeman and Soete, 1997). Schumpeter (1912) claimed that the process of creation and innovation increases firm profitability. The innovation procurement can be applied in R&D processes, such as in the application of new materials, the development of new products, the exploration of new markets, and the adoption of new management strategies. He indicated that R&D activities not only contribute to economic development but also play a significant role in business fluctuations. Pegels and Thirumurthy (1996) studied the relationship between R&D and firm performance, using data from 49 companies in 11 industrial sectors. They applied three-stage least square regression models and concluded that the accumulation of technological strength has a positive impact on operating income.

Sharma (2012) studied R&D and firm productivity in the Indian pharmaceutical industry. Using a Cobb-Douglas production function, he applied three models: the fixed effects model, the random effects model, and the GMM (Generalized Method of Moments) model. The results of the three models indicate that R&D enhances productivity. Pandit et al. (2011) considered the input and output of R&D as firm-level innovation. The input is R&D expenditure, and the output includes patent value and patent stocks. They estimated that the output of R&D has a positive impact on a firm's future performance.

Many studies show that the positive effects of R&D on a firm's performance are lagged. Ho and Tjahjapranata (2001) identified the time-lag effect as an essential element of R&D and firm performance. Hirschey and Weygandt (1985) indicated that R&D input increases profit returns with a 10-year time lag. Due to Chinese financial policy of the time, the research of Hou and Li (2010) is based on the special background that Chinese firms were not required to disclose their R&D expenditures before 2006, and their estimation does not focus on industry characteristic. They found that profit returns of R&D investments are observed in the first year, reach the maximum value in the third year, decrease from the fourth year and end in the eighth year.

Hsu and Chen (2013) studied the relationship of R&D expenditure, patents, financial returns and stock returns in high technology industries. They claimed that financial returns have a positive correlation with a two-year time lag of R&D expenditure and a one-year time lag of patents. The regression results showed that time is needed for investment in R&D, contributing to performance. R&D increases sales and stock returns, and it reduces profits by increasing operating expenses, especially in the first year. Furthermore, the lagged value of profits increases R&D expenditure, as well (Bogliacino and Pianta, 2012). Since the transformation of R&D and profits needs time, variables are lagged in this paper.

However, some studies provide an opposite conclusion. R&D could be uncertain and might fail to achieve its goals (Baker and Freeland, 1975). R&D expenditure boosts the development of innovation and technology, but some R&D projects might not be successful. Not all R&D effects would benefit firm performance (Mitchell and Hamilton, 1988). For example, Pandit et al. (2011) claimed that R&D expenditure has a negative impact on firm performance and increases the future volatility of firm value. Sun and Anwar (2014) studied the Chinese coal industry and claimed that R&D expenditure has no impact on firm profitability. However, their study did not consider lagged effects of R&D on profits, which may be the reason that statistical results were not significant.

2.2. Firm Size

Many studies emphasize the relationship between firm size and profitability. Large size means more profits for a firm (Amoroso, 2015). Pandit et al. (2011) used market capitalization to measure firm size. They claimed that firm size improves performance and decreases volatility. In addition, firm size is a determinant factor of the amount of R&D investment and has a positive impact on R&D expenditure (Bogliacino and Pianta, 2012).

However, Coad and Rao (2010) using the VAR model did not find a significant effect of firm size on R&D expenditure. Quo and Wang (2004) examined the effects of firm size and R&D on profits, using data from the Chinese software industry. They found that larger firms have lower profitability but higher productivity. We consider firm size as an independent variable in our panel data regression models and VAR models.

2.3. Leverage

Leverage is the debt to equity ratio (Kurt, 2013). He thought that firms can take financial loans if they must make more profits in the future. However, Pandit et al. (2011) claimed that leverage has a positive (negative) relationship with the firm’s volatility (future operating cash flow). A similar point of view is held by Khaddafi and Ummah (2014), and they also agree that leverage increases risk. The negative relationship between leverage and profitability has been proved in their study. Frank and Goyal (2014) also found that high debt to equity ratio weakens profitability.

In the debt market, the firm has more commercial activities when its size is large (Frank and Goyal, 2014). Ghosh (2012) studied Indian firms and verified that larger firms have higher leverage. He also studied the relationship between growth opportunities and leverage. The results indicate that the less-leveraged companies are more likely to develop and grow.

2.4. Education, R&D and Firm Performance

An educated labor force is an important factor of firm performance and profitability. It should be included as an input in the models to avoid the omitted variables' bias (Sougiannis, 2011). Implementation of R&D requires skilled workers. A highly educated workforce enhances firms' ability to acquire new technology. A highly trained labor force significantly increases firms' productivity (Bartel and Lichtenberg, 1985).

Banker and Wattal (2008) examined the impacts of the workforce education level on R&D behavior and firm's performance. They divided employees into two groups: highly educated employees (master and above) and university-educated employees. They found that the education level of the labor force increases R&D and firm performance. R&D conducted by firms with a highly educated workforce has a greater impact on firm performance. Ballot et al. (2001) analyzed the interactive effects of employees' education level and R&D on firms' added value. They found that well-trained and highly educated managers and engineers create more value-added for firms.

2.5. Interaction of R&D, Firm Size, and Leverage

Sridhar and Narayanan (2013) analyzed the dynamic and interactive relationship among R&D expenditure, inventory, advertising spending, and sales, with three vector autoregression models. The empirical results indicate that R&D investment has the most significant positive effect on firm's sales in the long term. Firms with better performance have the ability to expand R&D and advertising budget and to hold higher levels of inventory.

Also, inventory level is the primary consideration for firm managers when making a decision to increase R&D and advertising input or not. Ho and Tjahjapranata (2001) analyzed the relationship among R&D, firm size, leverage, opportunities, and firm growth. In their study, R&D and leverage were considered as interaction variables and firms were divided into two groups according to firm size. The results indicate that growth of small firms is positively affected by R&D and leverage, while R&D and leverage cause a slowdown in growth for large firms. They also found that firm size has an indirect positive impact on firms' growth, since firm size has a positive effect on R&D, which benefits growth.

3. Hypotheses

Based on the literature, we test the following hypotheses by estimating a panel data regression model:

Hypothesis (a): R&D expenditure has a positive effect on future firm performance.

Hypothesis (b): Larger firm size means better firm performance.

Hypothesis (c): Higher debt to equity ratio (leverage) reduces current and future profits.

We test the next two hypotheses by an interaction effects model:

Hypothesis (d1): Interaction effects of R&D and leverage are negative.

Hypothesis (d2): Interaction effects of leverage and firm size are positive.

The following hypotheses are tested by comparing the VAR models with moderating effects:

Hypothesis (e): Increased profits reduce the future debt to equity ratio.

Hypothesis (f): Increased profits increase future firm size.

Hypothesis (g): Larger firm size reduces the future debt to equity ratio.

Hypothesis (h): Larger firm size means higher future R&D expenditure.

Hypothesis (i): Increased R&D expenditure increases future firm size.

Hypothesis (j): A highly educated workforce increases the effects of R&D on firm performance.

4. Data and Variables

The collected datasets include data on Chinese public firms over the period 2009 - 2015. The public firms are listed at the Chinese A-share market, Shenzhen Stock Exchange, and Shanghai Stock Exchange. The data source is The Wind, which is one of the most authorized database search engines in China. The Chinese government, with updated financial policies in 2006, ordered the public firms to disclose their R&D expenditures. For this reason, we choose 2009 as the starting year to avoid the problems caused by missing data.

We choose operating profit as the dependent variable. Higher operating profit means better performance (Pandit et al., 2011). The data on operating profit are collected from annual financial statements at the end of the year.

R&D expenditures (R&D input) is the first control variable. For the firms who invest R&D activities, R&D expenditures improve firm performance (Branch, 1974). We focus on hypothesis (a): R&D spending has a positive effect on future firm performance. We only consider the first-order, second-order and third-order lag of R&D expenditure.

The second independent variable is the debt-to-equity ratio (DER). Kurt (2013, p. 2) figured out that the ratio of debt to equity is an indicator that reflects the leverage effects and volatility of profits. He also claimed that "no more than half of the company's assets should be financed by debt." Following his view, a debt-to-equity ratio of 0.5 is set as a boundary of volatility in our study. A high debt-to-equity ratio weakens firms' profitability (Frank and Goyal, 2014), which is hypothesis (c) in our paper.

Market capitalization is the third predictor variable in our study, and it is used to assess firm size (Hou and Li, 2010). Market capitalization is equal to "stock price and multiplying it by the total number of shares outstanding" (Investopedia, 2017). We examine the relationships between firm size and other variables to verify hypotheses (e), (f), and (g).

The education level of employees is a dummy variable in our study. The data are divided into two groups, one lower than a master's degree and the other higher or equal to a master's degree. The R&D program is operated by a highly educated workforce (Banker and Wattal, 2008**)**. The employees' education level is positively related to firm performance (Frank and Goyal, 2014). We estimate the difference between highly and lowly educated employees for R&D effort and firm performance.

The definition of variables is shown in Table 1. The monetary unit is the Chinese Yuan. All variables are in natural logarithms, except the education level.

Table 1: Abbreviations and Description of Variables

OPR: Operation profit
R&D: Research and development expenditure
LEV: Debt to equity ratio (leverage effect)
Size: Market capitalization
Educated Employees: The number of workers according to degree

Table 2 shows the Pearson correlation between estimated variables. All of the correlation coefficients are less than 0.24. The simple correlation does not indicate any strong linear relationship between variables. We conclude that there are no symptoms of multicollinearity in the data.

Table 2: Pearson Correlation Matrix of Variables

	Opr	R&D	Lev	Size
Opr	1.0000			
R&D	0.0425	1.0000		
Lev	0.0608	0.0288	1.0000	
Size	0.2381	0.1961	0.0536	1.0000

5. Methodology

5.1. Panel Data Regression Model

In this section, we estimate different panel data regression models to verify hypotheses (a), (b), (c), and (d). We are interested in estimating an individual-specific effects model with balanced panel data. The data represent the average of each industry over the period 2009 - 2015. This sample includes 77 observations, and we call it data I. The data I summary is shown in Table 9 in Appendix.

The 11 industries of the public firms are: information technology (IT), public service (PS), medical service (MS), industry (IND), real estate (RE), raw material (RM), telecommunication service (TS), energy resource (ER), financial institute (FI), current commodity (CC), and discretionary consumption (DC).

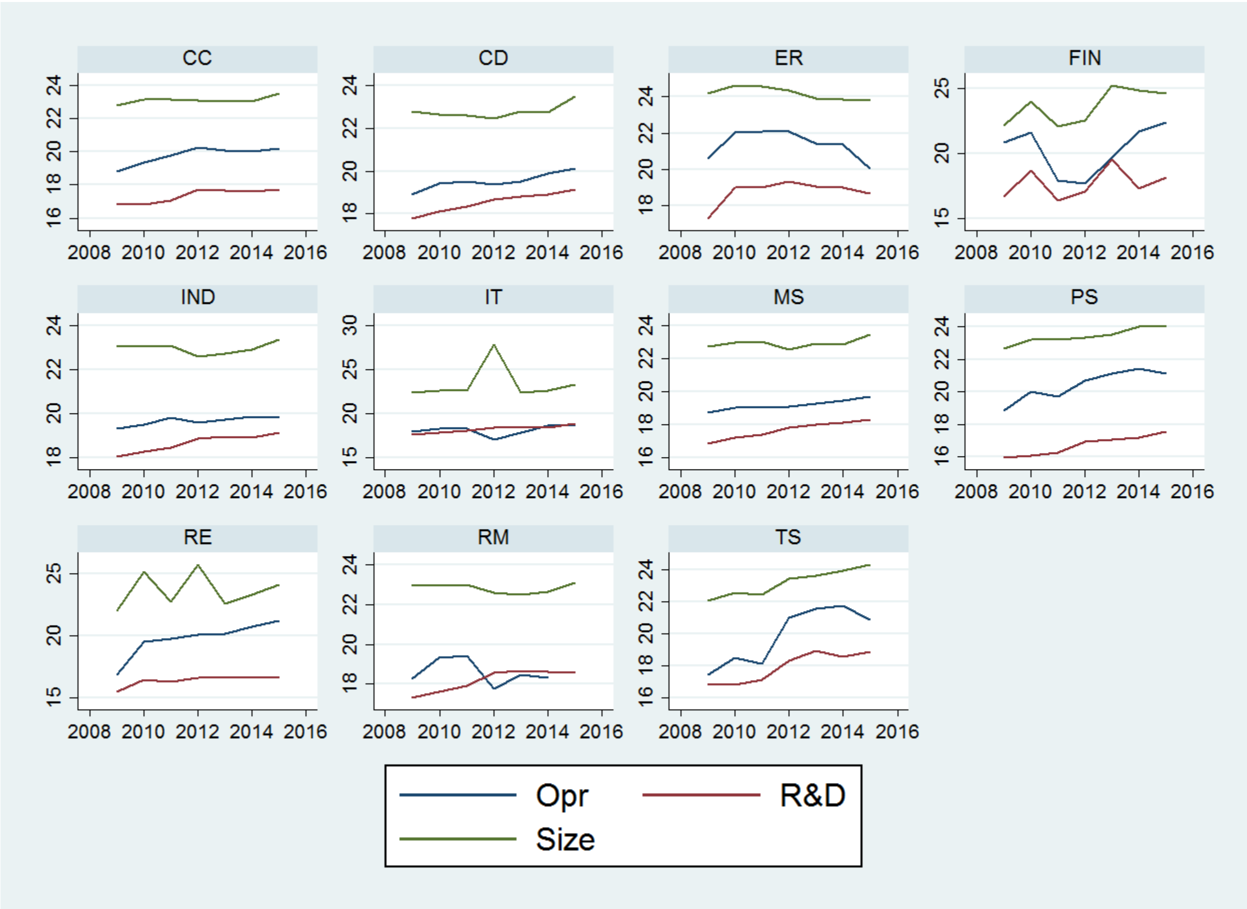
Each industry is seen as one cross-section unit over the period 2009 - 2015. Since the companies in the same industry face similar policies and regulations, such as government industrial subsidies, export rebates, or similarly upgraded products, we assume that heterogeneity exists only between different categories.

Five-panel data regression models are examined: pooled regression model, fixed effects model, least square dummy variable model, random effects model, and interaction effects model. We estimate the models with robust standard errors to correct heteroscedasticity. Then, we add industrial clustering to eliminate the correlated errors within subgroups.

Figure 1 shows the time-series trend of R&D expenditure, operating profit, and firm size by industry over the period 2009 - 2015. We find that the time trend of operating profit is different for each industry. Most of them are steady, such as CC: current commodity, CD:

discretionary consumption, IND: industry, and MS: medical service. However, the others exhibit fluctuations, such as FI: financial institute and RM: raw material.

Figure 1. Time Trends of Each Industry



5.1.1. Pooled Regression Model

The pooled regression model does not allow heterogeneity (Gujarati, 2010). We assume that the pooled regression result has a significant difference from that of the fixed and random effects models. Our pooled regression model is shown below:

$$OPR_{i,t} = \alpha + \beta_1 R\&D_{i,t-1} + \beta_2 R\&D_{i,t-2} + \beta_3 R\&D_{i,t-3} + \beta_4 LEV_{i,t} + \beta_5 SIZE_{i,t} + \varepsilon_{i,t} \quad (1)$$

where i denotes the industry, and t denotes the year.

5.1.2. Fixed Effects Model

For the fixed effects model, the intercept term of industries α is different from the equation above which generates specific effects (individual heterogeneity). The reason is that each intercept term is time-invariant which differs from the pooled regression model. The pooled regression model does not allow time-invariant variables. The individual heterogeneity is related to other independent variables (Gujarati, 2010). We rewrite Equation (1):

$$OPR_{i,t} = \alpha_{i,t} + \beta_1 R\&D_{i,t-1} + \beta_2 R\&D_{i,t-2} + \beta_3 R\&D_{i,t-3} + \beta_4 LEV_{i,t} + \beta_5 SIZE_{i,t} + \varepsilon_{i,t} \quad (2)$$

5.1.3. Least Square Dummy Variable Model

In LSDV model, the slope coefficients of the R&D expenditure, firm size and leverage are the same as the fixed effects model. The difference is that this model includes i-1 differential intercept dummies of industry to avoid the dummy-variable trap. The constant term represents the comparison industry, the industry of current commodity. The coefficients of the differential intercept provide information about the difference between the comparison industry and other industries (Gujarati, 2010). The coefficients of other independent variables are the same as the fixed effects model (Gujarati, 2010). For the dummy variables, we expect that the coefficients of industry, IT, raw material, and medical service are more different from the current commodity.

We rewrite Equation (2):

$$OPR_{i,t} = \alpha_{i,t} + \beta_1 R\&D_{i,t-1} + \beta_2 R\&D_{i,t-2} + \beta_3 R\&D_{i,t-3} + \gamma D_{2i} + \cdots + \gamma D_{11i} + \beta_4 LEV_{i,t} + \beta_5 SIZE_{i,t} + \varepsilon_{i,t} \quad (3)$$

where D_i=1 if the observation belongs to industry i and 0 if otherwise.

5.1.4. Random Effects Model

The error term in the random effects model includes two components: the individual specific error ε and the combined error ω of time series and cross-section. The unobserved heterogeneity α is not related to other independent variables (Gujarati, 2010).

We rewrite Equation (2) as:

$$OPR_{i,t} = \alpha + \beta_1 R\&D_{i,t-1} + \beta_2 R\&D_{i,t-2} + \beta_3 R\&D_{i,t-3} + \beta_4 LEV_{i,t} + \beta_5 SIZE_{i,t} + \varepsilon_i + \omega_{i,t} \quad (4)$$

5.1.5. Interaction Effects Model (Pooled Regression Model)

We expect the interaction effects model to verify hypothesis (d): Interaction effect of R&D and leverage is negative. If the coefficients of the interaction variables are positive, they have a complementary effect on each other. If the coefficients of the interaction variables are negative, they have substitutive effects mutually. We also anticipate the estimator of the interaction term of leverage and firm size to be positive since large firms have higher leverage (Ghosh, 2012). The equation to be estimated is shown below:

$$OPR_{i,t} = \alpha + \beta_1 R\&D_{i,t} + \beta_2 LEV_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 R\&D_{i,t} * LEV_{i,t} + \beta_5 R\&D_{i,t} * SIZE_{i,t} + \beta_5 LEV_{i,t} * SIZE_{i,t} + \delta_{i,t} \quad (5)$$

5.1.6. Hausman Test

Even though both fixed effects and random effects refer to individual-specific effects, we plan to compare the regression results of the models and select the optimal one with the aid of the Hausman test.

The null hypothesis for the Hausman test is that the individual effect is uncorrelated with explanatory variables. If the p-value of the statistic value is less than 0.05, the null hypothesis should be rejected, and the conclusion is that only fixed effects and the least square dummy variable model are consistent and efficient. However, if the p-value is greater than 0.05, we fail to reject the null hypothesis and conclude that the random effects model is both efficient and consistent (Gujarati, 2010).

5.2. VAR Model and Granger Causality

Hypotheses (e), (f), (g), (h), (i), and (j) are verified by the VAR model. Besides, we estimate whether Granger causality exists between variables. The VAR model is the first step for the Granger's causality test.

5.2.1. VAR Model

The VAR (Vector Autoregression) model is used to predict the system of multivariate time series (Abrigo and Love, 2015). "Each endogenous variable in the system can be transferred as the lagged value of these endogenous variables which creates a new function that can avoid the requirement from structural model" (Zellner and Palm, 2010, p. 105).

We estimate VAR models using a larger sample. We call it data II. The summary of data II is shown in Table 10. Data II includes 11,365 observations. Data II is an unbalanced panel since some firms do not provide continuous time-series data due to shut down or bankruptcy.

Each firm is an individual unit over the period 2009-2015. The individual heterogeneity of each industry is no longer considered in this section. The individual effect of each industry is dropped from our VAR models. Besides, we consider firm size, education and leverage as moderator variables. "The moderator variable is a variable that affects the direction and strength of the relation between a predictor variable and a dependent" (Baron and Kenny, 1986, p. 1174).

Our VAR models are based on the conception of causality from Granger (1969, p. 4). He defined that "the causality is that some X lead to a change in Y, and Y causes changes on X simultaneously," which he called "feedback relationship". His equation is as follow:

$$X_t + b_0 Y_t = \sum_{j=1}^{m} a_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + \varepsilon_t$$

$$Y_t + c_0 X_t = \sum_{j=1}^{m} c_j X_{t-j} + \sum_{j=1}^{m} d_j Y_{t-j} + \varphi_t$$

The left-hand side of the VAR equations is the current value of each variable. The right-hand side includes four lagged variables, which are R&D expenditure, leverage, firm size, and profits. We assume that all of the variables are endogenous. The VAR equations are shown below:

$$OPR_{i,t} = \beta_1 OPR_{i,t-k} + \beta_2 R\&D_{i,t-k} + \beta_3 LEV_{i,t-k} + \beta_4 SIZE_{i,t-k} \quad (6)$$

$$R\&D_{i,t} = \beta_1 R\&D_{i,t-k} + \beta_2 OPR_{i,t-k} + \beta_3 LEV_{i,t-k} + \beta_4 SIZE_{i,t-k} \quad (7)$$

$$LEV_{i,t} = \beta_1 LEV_{i,t-k} + \beta_2 R\&D_{i,t-k} + \beta_3 OPR_{i,t-k} + \beta_4 SIZE_{i,t-k} \quad (8)$$

$$SIZE_{i,t} = \beta_1 SIZE_{i,t-k} + \beta_2 R\&D_{i,t-k} + \beta_3 OPR_{i,t-k} + \beta_4 LEV_{i,t-k} \quad (9)$$

where i denotes the firm and t denotes the year.

5.2.2 Moderating Effect of Education Dummy Variable

The knowledge and experience of the labor force determine the R&D effort of a firm (Jokinen, 1998). Therefore, we expect that education has a moderating effect on the relationship between R&D input and firm performance. The dummy variable of the educational level of the workforce is used to verify whether a university-educated labor force has a moderating effect on the relationship between other variables. Firms can be divided into two groups, namely, lowly educated employees and highly educated employees. The description of the two education levels dummy variable is:

$$\begin{cases} \text{Educational level} = 1 & \text{if the degree is lower than master} \\ \text{Educational level} = 0 & \text{if the degree is master and above} \end{cases}$$

5.2.3. Moderating Effect of Firm Size

Firm size is divided into the large group and the small group by average firm size from Table 10. We expect that a small firm size (less than average) has a negative and moderating impact on the relationship between R&D expenditure and profits.

5.2.4. Moderating Effect of Leverage

In the VAR model, we suppose that high leverage (DER>0.5) weakens the relationship between R&D and profits. Our idea is based on a viewpoint from Kurt (2013, p. 2): “The DER is less than 0.5 which means firms face less volatility.”

5.2.5. Augmented Dickey-Fuller Unit Test and Granger's Test

Stationarity is a necessary condition for regression analysis, since non-stationary time-series data lead to spurious regression problems and an invalid central limit method, even in a large sample. The precondition for Granger's test is that data must be stationary (Gujarati, 2010). We apply the Augmented-Dickey-Fuller unit root test to determine whether the time series data are non-stationary. If the p-value is less than 0.05, we should reject the null hypothesis that a unit root exists. Then, we determine whether Granger causality exists among the variables of R&D expenditure, market capitalization, and operating profit after estimating the VAR models.

It is important to note that Granger causality does not represent the actual sense of causality, but a dynamic relationship among variables. In fact, it reflects whether a variable has the ability to predict another variable (White et al., 2009).

5.2.6. Information Criteria

In VAR models, we choose an appropriate number of lags from information criteria, which appears at the minimum value of both J's p-value and MBIC.

6. Empirical Results and Discussion

6.1. Results of Panel Data Regression Models

6.1.1. R&D Expenditure and Profits

The outputs of panel data models are shown in Table 11 in Appendix. In the first row, except for the result of the pooled regression model and interaction effects model, both estimators of the first-order lag of R&D expenditure in the fixed and random effects model are significant at a 5% level. When firms increase R&D input by 1%, operating profit rises by 0.314% and 0.268% under fixed effects and random effects, respectively, in the following year.

Besides, the coefficients of the second-order lag of R&D expenditure can be found in the second row. All of the coefficients are positive and significant at the level of 5%. One percentage increase of R&D improves profits by about 0.517% to 0.54% after two years. The utility of R&D input is maximized at the second year.

However, the third year's lagged value in R&D has a negative effect on profits. The firm’s profit is reduced by 0.45% in the fixed effects model and 0.485% in the random effects model. These results suggest that better firm performance cannot rely on the R&D input of three years ago. This result differs from the conclusion of Hou and Li (2010). They analyzed Chinese R&D expenditure over the period 2001 to 2006, and found that the utility of R&D expenditure reaches the maximum at the third-order lag.

We analyzed the regression results of R&D input and assumed that successful R&D products are put into the market and generate profits in the following two years. However, successful R&D expenditure is converted into intangible assets, and the rest that failed is seen as a loss in the financial statement at the third year (Hsu et al., 2013). Hypothesis (a): ‘R&D expenditure has a positive effect on future firm performance’ is supported when the lagged value of R&D input is equal to or less than two years.

6.1.2. Leverage and Profit

In previous studies, the leverage (debt-to-equity ratio) is another factor that influences firm performance. Leverage has a negative effect on profitability (Khaddafi and Ummah, 2014). The fourth row of Table 8 in Appendix gives regression results that support the view of Khaddafi and Ummah (2014). In the fixed effects model, if leverage increases by 1%, the operating profit will significantly diminish by 1.272%. The coefficient of leverage in the random effects model is close to the statistic value in the fixed effects model, which is -1.252 and significant at 1% level.

Hypothesis (c): ‘Higher debt to equity ratio (leverage) reduces profits’ is supported by our empirical results. The regression results imply that higher leverage leads firms to suffer more volatility since leverage increases firms’ volatility (Pandit et al., 2011).

6.1.3. Firm Size and Profits

The estimator of firm size is -0.183 with a p-value that is less than 1% in the fixed effects model, which implies that larger firm size does not mean higher profits. The conclusion of the random effects model is the same as the fixed effects model. However, hypothesis (b): ‘Larger firm size means better performance’ is not supported by statistical results. The regression results conflict with the conclusion that firms are more profitable when firm size is large (Yuan and Ming, 2011). However, we do not apply the lagged value of firm size, and the empirical result just reflects a relationship between firm size and profits during the same year.

6.1.4. Interaction Effect

The estimates of interaction variables appear in the fifth column in Table 8. The coefficient of interaction variables of R&D input and leverage is -2.543, which is significant at the 10% level. The interaction effect is substitutive between R&D and leverage. In other words, firms with higher debt-to-equity ratio will reduce their R&D expenditure. The first part of hypothesis (d): ‘The interaction effect of R&D and leverage is negative’ is verified by our regression result. R&D expenditure and leverage have a negative interaction effect on firm performance (Ho et al., 2001).

The interaction variable of firm size and leverage has a positive effect on profits, and the coefficient is 3.161 at 10% level of significance. Our regression result supports the conclusion that high leverage exists in large firms (Ghosh, 2012). Hypothesis (d2): 'The Interaction effect of R&D and leverage is positive' is supported by our model.

6.1.5. Hausman Test

Table 3: The Hausman and Wald Test Results

	---- Coefficients ----			
	(b) FE	(B) RE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
lrd				
L1.	0.3141	0.2681	0.0460	0.0328
L2.	0.5403	0.5170	0.0233	0.0132
L3.	-0.4496	-0.4854	0.0358	0.0248
lev	-1.2717	-1.2515	-0.0202	0.0263
lmv	-0.1829	-0.1608	-0.0222	0.0109
_cons	17.5704	18.8590	-1.2887	1.1818

Ho and Ha; obtained from xtreg
B =inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: oefficients not systematic
chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)=6.06
Prob>chi2 = 0.4169
(V_b-V_B is not positive definite)

The coefficients are very close between fixed and random effects models. In Table 3, the p-value for the Hausman test is 0.4196, which is higher than 0.10. Therefore, we fail to reject the null hypothesis that unobserved heterogeneity is uncorrelated with the independent variables. Only the random effects model is consistent and efficient simultaneously. We can conclude that the individual heterogeneity of each industry is not necessary for the models. Hence, the LDSV model is not efficient and does not provide credible results.

6.2. Results of VAR Model and Granger Causality

The VAR model requires variables that are related (Gujarati, 2010), and hypotheses (a), (c), and (d) are supported by previous results. The VAR model can be applied to examine bilateral causality. Furthermore, Granger's test is estimated to verify the causality among R&D

expenditure, operating profit, leverage, and firm size. All four variables are endogenous variables in the VAR model. The VAR estimates are presented in Tables 6, 7, and 8. We will analyze the moderating effects of employees' degree, firm size, and leverage, respectively.

6.2.1. The Information Criteria Result

The statistical values of the information criteria are shown in Table 4. The best value yields the minimum value of both J's p-value and MBIC, which appear in the first row. It confirms that the first-order lag of variables does satisfy the asymptotic properties of estimators (Greene, 2017).

Table 4: The Information Criteria Result of the VAR Model

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	.9972376	25.69936	.0118352	-62.67521	1.699355	-22.22091
2	.997431	16.26647	.0387211	-42.64991	.2664698	-15.68037
3	.9923828	8.435572	.0768644	-21.02262	.4355715	-7.537849

6.2.2. Stationarity Test

The statistic values of the stationarity test are shown in Table 5; all p-values are less than 0.01. This suggests that there is no unit root. The VAR model and Granger causality can be applied here.

Table 5: Fisher-ADF Unit Root Test

Fisher Test for panel unit root using an augmented Dickey-Fuller test				
	R&D	Profits	Size	Lev
Chi-Square	6126.6831	6575.8161	8789.2338	9446.8009
P-Value	0.000	0.000	0.000	0.000
Degrees of Freedom	2592	2592	2592	2592

6.2.3. Moderating effects of Employees' Education Level

Table 6 gives the results on the moderating effect of employees with different education levels. Firstly, if firms do not hire any employees with master's and Ph.D. degrees when profits increase by 1%, the R&D expenditure will rise by 0.93% in year t+1. However, with an increase of 1% in profits, the R&D expenditure increases 1.084% when firms hire employees with Ph.D. and master's degrees.

R&D expenditure has a positive and significant effect on subsequent profits, 0.22%, only for firms that hire employees with Ph.D. degrees and master's degrees. This result supports hypotheses (a): 'R&D expenditure has a positive effect on future firm performance' and (i): 'Increased R&D expenditure expands future firm size.' R&D expenditure has greater effects on future firm size when the firms' employees have Ph.D. or master's degrees. The coefficient is 3.225 and significant at 1% level. When firms hire highly educated workers, profits increase by 1%, and firm size expands by 0.93% in year t+1. Hypothesis (f): 'Increased profits increase future firm size' is only supported for the high-education level.

Table 6: VAR Results for Two Groups: High Education and University Education

	Educated Labor Force								
	Lower than Ph.D. and Master Degree					Higher than Ph.D. and Master Degree			
	OPR	RD	SIZE	LEV		OPR	RD	SIZE	LEV
L.opr	-0.548***	0.930***	0.524	-0.0548**	L.opr	-0.698***	1.084***	0.930**	-0.0726***
	(-3.86)	(2.76)	(0.97)	(-2.16)		(-6.67)	(5.86)	(2.25)	(-4.22)
L.rd	0.269	0.528**	2.679***	-0.104***	L.rd	0.222**	0.509***	3.225***	-0.100***
	(1.50)	(2.49)	(4.82)	(-3.65)		(2.15)	(4.28)	(8.48)	(-5.83)
L.size	-0.245**	0.132	-0.951***	0.110***	L.size	0.0227	-0.0367	-1.659***	0.113***
	(-2.00)	(1.02)	(-2.80)	(5.43)		(0.30)	(-0.42)	(-5.70)	(8.13)
L.lev	1.166**	0.0222	-14.53***	0.133	L.lev	0.634*	0.153	-20.29***	0.186***
	(2.31)	(0.04)	(-8.97)	(1.63)		(1.81)	(0.36)	(-12.81)	(2.76)
No. of Obs.	1324				No. of Obs.	3238			

t statistics in parentheses *** p<0.01 **p<0.05 *p<0.10

6.2.4. Moderating Effects of Firm Size

We define firm size as large (small) when its market capitalization is higher (lower) than the average value. The VAR results are shown in Table 7.

If profits of small firms increase by 1%, future R&D expenditure will increase by 1.32%, which is greater than that of large firms. If R&D expenditure increases by 1%, future profits will decrease by 0.254%. Hypothesis (a): 'R&D expenditure has a positive effect on future firm performance' is not supported by our results. If R&D expenditure rises by 1%, future firm size will expand by 3%. However, firm size has a negative effect of 1.57% on future profits.

If large firms increase R&D expenditure by 1%, as a result, future profits will rise by 1.784%, and future firm size will expand by 10.24%. The results support hypothesis (a): 'R&D expenditure has a positive effect on future firm performance' and hypothesis (i): 'Increased R&D expenditure increases future firm size.' If firm size expands by 1%, future R&D expenditure will increase by 0.471%, which supports hypothesis (h): 'Larger firm size means higher future R&D expenditure.'

Profits of both types of firm sizes have negative effects on future leverage. If profits increase by 1%, the future debt to equity ratio will decrease by 0.065% to 0.089%. These results support hypothesis (e): 'Increased profits reduce future debt to equity ratio.'

Table 7: VAR Results for Two Groups: Large Firm Size and Small Firm Size

Firm Size									
	Relative Small Size					Relative Large Size			
	OPR	RD	SIZE	LEV		OPR	RD	SIZE	LEV
L.opr	-0.702***	1.320***	0.975*	-0.0890***	L.opr	-0.567*	0.732***	2.972	-0.0652**
	(-5.77)	(3.87)	(1.82)	(-3.33)		(-1.67)	(3.39)	(1.51)	(-2.21)
L.rd	-0.254*	1.045***	3.001***	-0.125***	L.rd	1.784***	-0.486	10.24**	-0.148**
	(-1.93)	(4.83)	(6.34)	(-5.07)		(2.61)	(-1.29)	(2.38)	(-2.26)
L.size	-0.157**	0.00409	-1.489***	0.118***	L.size	-0.579	0.471*	-6.000**	0.139***
	(-2.22)	(0.04)	(-6.15)	(8.35)		(-1.24)	(1.87)	(-2.01)	(2.98)
L.lev	-0.0713	1.384**	-17.42***	0.155**	L.lev	-8.678	4.729*	-79.29**	0.624
	(-0.22)	(2.35)	(-13.59)	(2.43)		(-1.63)	(1.69)	(-2.36)	(1.28)
No. of Obs.	2514				No. of Obs.	1888			

t statistics in parentheses *** p<0.01 **p<0.05 *p<0.10

6.2.5. Moderating Effects of Leverage

In Table 8, all of the statistic results of the firms with high debt to equity ratios are not significant. We discuss the case of firms that have a low debt to equity ratio.

If R&D input increases by 1%, future profits will rise by 0.358%. When profits rise by 1%, R&D expenditure will increase by 0.829%. Hypothesis (a) is supported by VAR results when leverage is low. This result is different from the study of Li and Hwang (2011). They concluded that R&D had a positive relationship with earnings when leverage is high. Besides, hypothesis (i) can be verified because if R&D increases by 1%, future size will expand by 4.371%.

In addition, we fail to verify hypothesis (f), which is that profits increase future size. Hypothesis (g) is not supported in this case since if firm size expands by 1%, future leverage increases by 0.182%. We cannot prove hypothesis (h) that larger firm size means higher future R&D expenditure. When firms have high volatility, all of the statistical results are not significant and cannot provide any information.

Table 8: VAR Results for Two Groups: High DER and Low DER.

Leverage									
	Relative Low Debt to Equity Ratio					Relative high Debt to Equity Ratio			
	OPR	RD	SIZE	LEV		OPR	RD	SIZE	LEV
L.opr	-0.530***	0.829***	0.756	-0.124***	L.opr	2.130	7.875	5.363	-1.918
	(-6.54)	(5.03)	(1.50)	(-3.77)		(0.08)	(0.13)	(0.16)	(-0.11)
L.rd	0.358***	0.473***	4.371***	-0.245***	L.rd	3.135	6.895	6.237	-1.889
	(2.81)	(3.76)	(7.47)	(-6.13)		(0.12)	(0.11)	(0.20)	(-0.11)
L.size	-0.106	0.0731	-1.996***	0.182***	L.size	-12.48	-28.38	-15.98	8.421
	(-1.43)	(1.02)	(-5.71)	(7.34)		(-0.11)	(-0.11)	(-0.11)	(0.11)
L.lev	1.234***	-0.0772	-15.49***	0.00885	L.lev	83.06	195.0	66.12	-57.57
	(4.58)	(-0.28)	(-12.46)	(0.11)		(0.10)	(0.11)	(0.07)	(-0.11)
No. of Obs.	3490				No. of Obs.	1072			

t statistics in parentheses *** p<0.01 **p<0.05 *p<0.10

6.2.6. Granger's Causality Test

All four variables on the right-hand side of equations (6), (7), (8), and (9) are excluded variables that have an ability to predict the dependent variable. If the p-value in the test is less than 0.05, the null hypothesis for that excluded variable does not Granger-cause the equation variable and should be rejected. After conducting comparative statistical results in Table 12 in the Appendix, we can conclude that the causal relationship between firm size and leverage appears in each result of Granger's test, which means firm size always has a positive effect on leverage. Firms tend to carry more debt when they are large (Frank and Goyal, 2014). However, excessive leverage leads to downsizing.

The second conclusion is that the causal relationship between profits and leverage exists in small firms, firms with low volatility, and firms with highly educated employees. In this case, firms suffer the debts but will gain profits in the following year. However, increased leverage will lead to poor performance in the future.

Another finding is that the causal relationship of R&D and profits does not appear in firms that only hire employees with bachelor or college degrees. Moreover, if firms are small, their R&D expenditure has a negative effect on future performance.

R&D and firm size have a predictive impact on each other only for large firms. The causal relationship of profits and firm size depends on whether firm size is small. In addition, R&D and firm size have mutually positive effects only for large firms.

7. Conclusion

This study investigates the relationship between firm profits, R&D expenditure, firm size and financial leverage in China over the period 2009-2015. We applied panel regression models and VAR models to verify hypotheses (a) to (i).

Hypothesis (a): R&D expenditure has a positive effect on future firm performance. Both of our panel regression results and VAR model results support that R&D has a lagged and positive effect on firm performance.

Hypothesis (b): Larger firm size means better firm performance. We fail to prove this hypothesis in the panel regression model and conclude that firm size has a negative effect on firm performance in the current year.

Hypothesis (c): Higher debt to equity ratio (leverage) reduces profits. High leverage means that firms face more volatility of profits (Pandit et al., 2011). This hypothesis is supported by panel data regression results, but the VAR model results make a different extension that leverage has a positive impact on future profit.

Hypothesis (d1): Interaction effects of R&D input and leverage are negative. Hypothesis (d2): Interaction effects of leverage and firm size are positive. Hypotheses (d1) and (d2) imply that R&D input and leverage are substitutes, while firm size and leverage are complementary. Furthermore, the results of the VAR model suggest that firms expand their sizes because of more debts in the future.

Hypothesis (e): Increased profits reduce the future debt to equity ratio. When this hypothesis is correct, the necessary condition is that leverage should be lower than 0.5.

Hypothesis (f): Increased profits increase the future firm size. When this hypothesis is correct, the original firm size is small.

Hypothesis (g): Larger firm size reduces the future debt to equity ratio. This hypothesis is not supported by the results of VAR models. In fact, larger firm size means higher future debt to equity ratio.

Hypothesis (h): Larger firm size means greater future R&D expenditure. When firm size is higher than the average size of all firms, R&D expenditure will increase in the following year.

Hypothesis (i): Increased R&D expenditure increases future firm size. When firm size is smaller than the average size, R&D expenditure will increase firm size in the following year. Hypothesis (j): A highly educated workforce increases the effects of R&D on firm performance. R&D expenditure has positive effects on profits only when firms hire a highly educated labor force.

Overall, the first-order lag of R&D can improve the current operating profit, but the second-order lag of R&D has a greater effect than the first-order lag. Besides, firm performance is affected by the leverage effect that leads to reduced profits and high volatility (Khaddafi and Ummah, 2014). Unobserved heterogeneity (for each industry) is uncorrelated with other independent variables. Hence, the random effects model is the optimal one in this research. Otherwise, the VAR models verify that some pairs of operating profit, R&D input, leverage, and firm size have predictive power on each other under different moderating effects. We study the changes in the relationship of R&D expenditure and firm performance regarding the educational moderating effect and suggest that hiring highly educated employees improves the link between R&D input and profits.

In future research, Firms could be divided precisely to the different level of industries, such as hi-tech and low-tech, which have different proportions of R&D inputs. Besides, market capitalization should be classified to large cap, middle cap, and small cap. The effect of R&D on firm performance may change due to this adjustment. The period of our model cannot reflect long-term trend, and long-term success makes more sense than short-term effects of R&D

(Lerner and Wulf, 2007). Besides, R&D intensity is another observable factor to estimate how R&D activities cause changes in firm performance (Yeh et al., 2010).

Appendix

Table 9: Data I Summary

Variable		Mean	Std. Dev.	Min	Max	Observations
R&D	overall	17.82926	0.9575	15.43503	19.54023	N = 77
	between		0.77562	16.38796	18.74977	n = 11
	within		0.602257	16.38562	19.70615	T = 7
Opr	overall	19.70203	1.276683	16.88702	22.3799	N = 76
	between		0.880209	18.123	21.38819	n = 11
	within		0.960804	16.82977	21.82174	T = 6.90909
Size	overall	23.28514	0.94678	22.01756	27.81243	N = 77
	between		0.437744	22.78042	24.1814	n = 11
	within		0.848469	21.6229	27.70975	T = 7
LEV	overall	0.547948	0.702883	0.099	5.3535	N = 77
	between		0.422181	0.2508132	1.783879	n = 11
	within		0.574351	0.762188	4.117569	T = 7
Year	overall	2012	2.013115	2009	2015	N = 77
	between		0	2012	2012	n = 11
	within		2.013115	2009	2015	T = 7
Industry	overall	6	3.183014	1	11	N = 77
	between		3.316625	1	11	n = 11
	within		0	6	6	T = 7

Table 10: Data II Summary

Variable		Mean	Std. Dev.	Min	Max	Observations
R&D	overall	17.1918	1.468242	6.907755	23.22474	N = 11365
	between		1.387145	9.9583	22.79497	n = 2505
	within		0.716032	10.06012	21.41942	T-bar = 4.53693
Operating Profit	overall	18.46628	1.431987	11.25398	25.28615	N = 11365
	between		1.329845	12.09588	25.24892	n = 2505
	within		0.6847518	13.20447	23.29799	T-bar = 4.53693
Market Value	overall	4.130189	0.963036	0.3965566	8.851982	N = 8908
	between		0.8505553	2.208736	8.801602	n = 2257
	within		0.4866922	0.0462323	7.587605	T-bar = 3.94683
Leverage	overall	0.3871586	0.2016369	0.0075	2.394002	N = 11365
	between		0.1884522	0.0259	1.5052	n = 2505
	within		0.0908241	0.0300007	1.7631	T-bar = 4.53693
PHD	overall	2.238331	16.81868	0	867	N = 11365
	between		14.1296	0	492.6667	n = 2505
	within		10.6462	197.5617	744.9526	T-bar = 4.53693
Master	overall	97.75073	580.5518	0	22477	N = 11365
	between		634.2575	0	20402.67	n = 2505
	within		156.7242	3845.449	6012.551	T-bar = 4.53693
Bachelor	overall	887.1681	4670.151	0	121893	N = 11365
	between		4586.988	0	104189	n = 2505
	within		874.4834	35519.83	18591.17	T-bar = 4.53693
College	overall	995.7969	4495.73	0	161828	N = 11365
	between		3944.489	0	92428.6	n = 2505
	within		2084.72	91432.8	85795.51	T-bar = 4.53693

Table 11: Panel Data Regression Model

	Pooled	FE	LSDV	RE	IE
	Opr	Opr	Opr	Opr	Opr
L1.rd	0.116	0.314***	0.314***	0.268***	
	(-0.64)	(-3.83)	(-3.27)	(-4.41)	
L2.rd	0.351**	0.540***	0.540***	0.517***	
	(-2.5)	(-4.74)	(-4.05)	(-5.19)	
L3.rd	0.698***	0.450**	0.450**	0.485***	
	(-3.17)	(-2.82)	(-2.41)	(-3.66)	
rd					0.946
					(-0.21)
lev	0.635**	1.272***	1.272***	1.252***	28.13**
	(-3.10)	(-18.74)	(-16.01)	(-17.94)	(-2.37)
size	0.223	0.183***	0.183***	0.161**	2.793
	(-0.56)	(-4.35)	(-3.71)	(-2.51)	(-0.67)
DC			0.959**		
			(-2.60)		
ER			0.575		
			1.05		
FIN			523***		
			(-8.7)		
IND			0.937*		
			(-2.21)		
IT			2.364***		
			(-7.61)		
MS			1.114***		
			(-14.94)		
PS			487***		
			6.35		
RE			201***		
			(-4.54)		
RM			2.441***		
			(-12.02)		
TS			0.746***		
			(-5.06)		
R&D*LEV					2.543*
					(-1.85)
R&D*SIZE					0.104
					(-0.5)
LEV*SIZE					3.161*
					(-2.04)
CONSTANT	18.99	17.57***	17.73**	18.86***	58.02
	(-1.43)	(-3.2)	(-2.83)	(-4.35)	(-0.67)
N	43	43	43	43	76

t statistics in parentheses *** p<0.01 **p<0.05 *p<0.10

Table 12: Panel VAR-Granger Causality Wald Test

Ho: Excluded variable does not Granger-cause Equation variable

Ha: Excluded variable Granger-causes Equation variable

University Education					higher University Education				
Opr	Excluded	Chi2	df	p-value	Opr	Excluded	Chi2	df	p-va
	R&D	2.239	1	0.135		R&D	4.622	1	0.0
	Size	4.019	1	0.045		Size	0.092	1	0.7
	LEV	5.32	1	0.021		LEV	3.271	1	0.0
R&D	Excluded				R&D	Excluded			
	Opr	7.593	1	0.006		Opr	34.363	1	0.0
	Size	1,036	1	0.309		Size	0.173	1	0.6
	LEV	0.002	1	0.969		LEV	0.129	1	0.7
Size	Excluded				Size	Excluded			
	Opr	0.949	1	0.330		Opr	5.077	1	0.0
	R&D	23.209	1	0.000		R&D	71.903	1	0.0
	LEV	84.524	1	0.000		LEV	164.086	1	0.0
LEV	Excluded				LEV	Excluded			
	Opr	4.669	1	0.031		Opr	17.841	1	0.0
	R&D	13.317	1	0.000		R&D	33.984	1	0.0
	Size	29.537	1	0.000		Size	66.077	1	0.0
Small Firm Size					Large Firm Size				
Opr	Excluded	Chi2	df	p-value	Opr	Excluded	Chi2	df	p-va
	R&D	3.742	1	0.053		R&D	6.829	1	0.0
	Size	4.95	1	0.026		Size	1.528	1	0.2
	LEV	0.049	1	0.825		LEV	25.495	1	0.1
R&D	Excluded				R&D	Excluded			
	Opr	15.013	1	0.000		Opr	11.482	1	0.0
	Size	0.002	1	0.967		Size	3.514	1	0.0
	LEV	5.528	1	0.019		LEV	2.845	1	0.0
Size	Excluded				Size	Excluded			
	Opr	3.295	1	0.069		Opr	2.286	1	0.1
	R&D	40.225	1	0.000		R&D	5.683	1	0.0
	LEV	184.778	1	0.000		LEV	5.581	1	0.0
LEV					LEV				
	Opr	11.081	1	0.001		Opr	4.877	1	0.0
	R&D	25.754	1	0.000		R&D	5.092	1	0.0
	Size	69.677	1	0.000		Size	8.909	1	0.0

Table 13: Panel VAR-Granger Causality Wald Test continued

Low Leverage					High Leverage				
Opr	Excluded	Chi2	df	p-value	Opr	Excluded	Chi2	df	p-value
	R&D	7.884	1	0.005		R&D	0.014	1	0.906
	Size	2.033	1	0.154		Size	0.012	1	0.914
	LEV	20.95	1	0.000		LEV	0.011	1	0.917
R&D	Excluded				R&D	Excluded			
	Opr	25.326	1	0.000		Opr	0.016	1	0.898
	Size	1.034	1	0.309		Size	0.012	1	0.914
	LEV	0.08	1	0.778		LEV	0.012	1	0.914
Size	Excluded				Size	Excluded			
	Opr	2.239	1	0.135		Opr	0.027	1	0.870
	R&D	55.841	1	0.000		R&D	0.038	1	0.845
	LEV	155.144	1	0.000		LEV	0.005	1	0.945
LEV	Excluded				LEV	Excluded			
	Opr	14.223	1	0.000		Opr	0.011	1	0.916
	R&D	37.522	1	0.000		R&D	0.011	1	0.915
	Size	53.924	1	0.000		Size	0.012	1	0.914

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