RD Investments and Idiosyncratic Volatility

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Abstract

This paper investigates how R&D investment intensity can infuse information asymmetry about the growth prospects and the idiosyncratic volatility of non-financial firms. Panel Data Method has been employed in order to regress idiosyncratic volatility on R&D investments. Using a sample of research-intensive FTSE-100 and S&P-100 firms having the highest market capitalization between 2008 and 2017, the study finds the evidence of a positive association in between R&D investment intensity and idiosyncratic component of total stock return volatility. The study provides the insight that R&D-led firms should leverage on their R&D related sensitive information to reduce the level of idiosyncratic volatility.

Keywords: R&D, Idiosyncratic Volatility, Firm Size, Information Asymmetry

JEL Codes: G1, G12, G15

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1.0 Introduction

Total stock return volatility typically determines the overall financial risk of a firm. This volatility measure can be classified into two forms, for instance, market- related risk or systematic risk, and firm-specific risk or idiosyncratic risk. Campbell et al. (2001) show that firm specific idiosyncratic risk, i.e. the degree to which firm specific returns are more volatile than average market returns, has risen since the 1960s. R&D investments are pretty unique to the companies that execute the projects. As a result, R&D is accountable for generating asymmetry in information transmission about the firms' future prospects and growth potentials. In this connection, Aboody and Lev (2000) find the evidence that the distinctiveness of R&D investments makes it difficult for general investors (the outsiders) to learn about the productivity and worth of a particular company's R&D. This may critically contribute to the information asymmetry for the R&D intensive firms relative to those having no R&D attempts. Accordingly, Gu and Wang (2005) provide the evidence that the extent of informational asymmetry in high-tech R&D driven companies is high because of the complication and technical features of innovation.

A large body of literature explores the riskiness of R&D investments and document that R&D intensive firms are riskier than those with no R&D intensity (Chan et al. 2001; Kothari et al. 2002). Goyal and Clara (2003) evaluate the similar association and exhibit that idiosyncratic volatility has a significant impact on the required rate of return on the stock market. Furthermore, Xu (2006) examines how R&D strategies of US biotech companies influence their stock price volatility. Taylor (2008) also derives the evidence that the presence of idiosyncratic volatility enhances the quality of market volatility predictions. And, Kearney and Poti (2008) report the similar empirical results for the European capital markets. The finding of Mazzucato and Tancioni (2008) supports the insight that the more the R&D intensity a firm has, the greater would be its consequent idiosyncratic risk. Later on, Gharbi et al. (2013) examine the relationship between R&D investments and hi-tech firms' return volatility from the context of France and find the evidence of a strong positive nexus between R&D investments intensity and idiosyncratic risk.

Up until now most of the earlier studies exclusively concentrate on the United States. This is because; the US firms constantly invest more in R&D activities than the European nations (Moncada et al. 2010). Moreover, studies on European context hardly exist explicitly from the background of the United Kingdom. Hence, the present research proposes R&D investment as a likely determinant of the idiosyncratic volatility for the non-financial research-oriented UK firms under the FTSE-100 Index and the non-financial research-led US firms under the S&P-100 Index.

R&D largely relies on size, gross profit margin, and nature of business. Undoubtedly, R&D expenditures are very much distinctive to a particular company. The more the R&D investments made by a company, the greater will be its variability in the business activities and expected financial success. Hence, it is anticipated that R&D intensity is more linked to the idiosyncratic part of total volatility. Therefore, the study develops the following hypothesis:

Idiosyncratic stock volatility is positively associated with the R&D investments.

The rest of the paper is organized as follows:

Chapter 2 focuses on the data and methodology of the study. Chapter 3 provides the summary measures of the study, i.e. key features of the data collected from both the UK and the USA perspective. Chapter 4 covers the analysis and discussion of the empirical results. Finally, Chapter 5 presents the conclusion, implications of the study, and the scope of further research.

2. Data and Methodology

2.1 Details of the variables

Idiosyncratic Volatility (IDV)

The capital markets do not explain the idiosyncratic volatility or firm specific risk. So, Idiosyncratic volatility has little or no association with systematic or market risk factor. However, idiosyncratic volatility is very specific to a firm. For instance, if a firm has to close down a major plant because of a natural calamity, its share price may be affected whereas the rest of the market remains unaffected. Equivalently, R&D expenditures are unique to a firm.

In the past, researchers employ several proxies to represent idiosyncratic volatility. For instance, Mazzucato and Tancioni (2012) consider a proxy for idiosyncratic risk which captures the degree to which firm-specific returns are more volatile than the average industry returns: the log ratio between the standard deviation of a firm's return and the standard deviation of the average industry return. However, Gharbi et al. (2013) define idiosyncratic volatility as the annualized standard deviation of weekly errors from the CAPM. Using the same formula in this study, idiosyncratic volatility has been characterized by the annualized standard deviation of weekly errors from the Capital Asset Pricing Model (CAPM) in each year. Therefore, natural logarithm of idiosyncratic volatility (IDV) is regarded as the response variable.

R&D Expenditures

The study regards R&D as the ratio of R&D expenses to sales. Net sales or revenue has been treated as Sales. Total assets represent the size of the firm. Natural logarithm of total assets is utilized. This logarithmic transformation reduces both skewness and kurtosis and helps obtain the end results fairly closer to the normal distribution. Table 01 lists the definition of all the variables along with abbreviations.

Name of the variable	Abbreviation	Definition
Idiosyncratic Volatility	IDV	Annualized standard deviation of weekly errors from the CAPM Model
R&D Expenditures	R&D (RnD in Stata)	The ratio of R&D Expenditures to Sales
Size of the firm	SIZE	Natural logarithm of Total Assets of a firm
Leverage	LEVERAGE	The ratio of Total Debt to Total Assets

Table 01: Definitions of variables employed in this study

Besides, the study encompasses two control variables. Control variables, for example, size and leverage, are broadly acknowledged as determinants of stock return volatility. Here, Leverage is categorized as the ratio of total debt to total assets of a company. In addition, Size is generally measured as the total assets of a company. The logarithm of total assets is taken as a control variable to derive the estimations. Two control variables included in this study are meant to limit the bias of omitted variables and ensure the legitimacy of the regression model.

2.2 Sample

S&P-100 is the most remarkable stock market indicator in the world that incorporates the largest 100 US firms according to strong company fundamentals and highest market capitalization. The S&P 100 index is a subgroup of the broad S&P 500 index. S&P 100 accounts for about 63% of the market capitalization of the S&P 500 index and also represents almost 51% of the entire market capitalization of the US equity markets as of June 2017. While FTSE-100 is by far the most widely used UK capital market indicator. FTSE 100 occupies around 81% of the entire market capitalization of the London Stock Exchange (LSE). FTSE-100 firms are taken into account.

Since, the present study is based on both the UK and the US context, it comprises two independent groups of sample data for the research.
Table 02 shows the sample summary of this research:

TARGET INDEX	NUMBER OF TOTAL NON-FINANCIAL COMPANIES	NUMBER OF COMPANIES WITH R&D INTENSITY	CROSS SECTIONS OF SAMPLE	TIME SERIES OF SAMPLE (YEARS)
FTSE-100	79	43	43	10
S&P-100	84	70	70	10

Table 02: Overview of final sample of the study

Datastream 5.0 version has been accessed to accumulate necessary data for the study. Altogether, five variables, regarding company performance indicators and business activities, have been downloaded from Datastream. Each data set covers information of eligible sample firms for a period of 10 years between 2008 and 2017. The study concentrates on a balanced panel that is labeled as *strongly balanced by the data processing software, STATA.* Every single firm underlying the study has been observed each year.

2.3 Model Specification

In order to choose the appropriate model fit, pooled OLS estimation, the fixed effects model, and the random effects model are taken into account in this study. All the three models are demonstrated below:

i) Pooled Regression: Pooled OLS applies the same constant α for all the sample firms. The model can be signified as:

$$Y_{it} = \alpha + \beta' X_{it} + \varepsilon_{it} \qquad (1)$$

ii) The Fixed Effects Model: The fixed effects model permits the constant to vary between firms, however, it is time invariant. The coefficients (α_i) make the difference, which indicate unobservable heterogeneity or individual firm specific effects. The fixed effects model is shown below:

$$Y_{it} = \alpha_i + \beta' X_{it} + \varepsilon_{it} \qquad (2)$$

iii) Random Effects Model: The random effects model entitles the constant variable as a random variable that can be shown in the form as follows:

$$\alpha_i = \alpha + u_i \qquad (3)$$

Overall, this model can be written as:

$$Y_{it} = \alpha + \beta' X_{it} + u_i + \varepsilon_{it} \qquad (4)$$

To select the correct specification, the study conceives three tests. First, the F-test approves the significance of the fixed effects. Second, The Breusch and Pagan (1980) Lagrangian Multiplier test evaluates the relevance of the random effects. Third, the Hausman test (1978) distinguishes between the fixed effects model and the random effects model.

All the variables are winsorized at both upper and lower levels at 1% of their distribution in a manner to curb the impact of the outliers on the estimated results.

3.0: Summary Statistics

Table 03 presents the summary Statistics of the UK firms within the FTSE-100 Index. Firm specific or idiosyncratic volatility measure shows an average of 44%. Average R&D investment intensity is moderate for the giant firms. UK firms allocate, on average, 2.5% of their sales to R&D endeavor. The standard deviation of R&D is 4.70%.

Variable	Observations	Mean	Standard Deviation	Min	Max
R&D	430	2.524	4.704	0	26.13
TOTAL ASSETS (Size)	430	15.88	2.404	1	19.74
DEBT TO ASSETS (Leverage)	430	26.884	15.233	0	72.21
IDIOSYNCRATIC VOLATILITY (IDV)	430	.4388	.27423	0	1.746
LN (IDV)	430	-.90596	0.53612	2.09481	0.55770

Table 03: Summary statistics of the UK firms under the FTSE-100

Table 04, similarly, lists the summary statistics of the research-driven US firms within the S&P-100 Index. Here, idiosyncratic volatility measure stands at 39% on average. The biggest US firms invest, on average, 7% of their sales into R&D activity.

Variable	Observations	Mean	Standard Deviation	Min	Max
R&D	700	6.823	8.162	0	45.49
TOTAL ASSETS (Size)	700	17.311	2.782	1	20.497
DEBT TO ASSETS (Leverage)	700	25.509	18.337	0	156.61
IDIOSYNCRATIC VOLATILITY (IDV)	700	.38988	.22282	0	1.50987
LN (IDV)	700	-.96000	.51270	-2.21324	.41202

Nonetheless, the standard deviation of R&D investment intensity is little over 8%.

Table 04: Summary statistics of the US firms under the S&P-100

Skewness and Kurtosis of the volatility measures are as follows:

UK context	Skewness	Kurtosis	US context	Skewness	Kurtosis
IDV	1.652157	6.83381	IDV	1.255829	5.959843
LN (IDV)	0.292247	2.570396	LN (IDV)	0.240298	2.778884

Table 05: Summary details of idiosyncratic volatility

The volatility measure shows high magnitude of skewness and kurtosis. But log-transformation lowers the level of skewness and kurtosis considerably. So, the distributions of the log-transformed variables are close to the normal distribution.

4.0: Empirical Results

Impact of R&D on the idiosyncratic volatility (IDV)

This study applies the following model to estimate the expected link between R&D investment intensity and idiosyncratic volatility:

$$IDV_{it} = \beta_0 + \beta_1 R\&D_{it} + \beta_2 Leverage_{it} + \beta_3 Size_{it} + \varepsilon_{it}$$

Independent variables	FTSE-100 (UK)	S&P-100 (US)
R&D	0.0605**	0.0127***
	(3.07)	(3.82)
Leverage	0.00697***	-0.00147*
	(3.77)	(-2.10)
Size	-0.0781**	-0.0415***
	(-2.64)	(-3.42)
Constant	1.365**	1.057***
	(3.01)	(5.29)
	N=430	N=700

t statistics are in parentheses. Asterisks indicate significance level
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 10: Effects of R&D on idiosyncratic volatility

The above table shows the regression results regarding the relationship between R&D investment intensity and idiosyncratic volatility. At first, Breusch and Pagan Lagrangian multiplier test has been performed. Significant p value of Breusch and Pagan Lagrangian multiplier test has suggested that random effects model is more fitting than the pooled OLS estimation (Breusch and Pagan LM statistic: 140.87 with a P value of 0.0000). Then, the study conducts the Hausman test to pick the appropriate specification between fixed effects and random effects. Finally, significant p value corresponding to Hausman test score recommends that fixed effects model is more suitable than the random effects model. The test result along with p value is given under:

Hausman test = 17.18
Prob > chi2 = 0.0006

Since the Hausman test statistic is significant at less than 1% level, the fixed effects model specification has been chosen. In this model, idiosyncratic volatility has been regressed. Here, R&D intensity is the major explanatory variable along with two control variables. Control variables are Leverage and firm size. The estimated coefficients are 0.0605 and 0.0127 for the UK and the US respectively. The coefficients are positive and significant at the 1% level for the FTSE-100 and 0.1% level for the S&P-100. In fact, R&D intensity is always exclusive to a firm. A firm can engage in more R&D activities or can do nothing at all. As a result, the impact of R&D investments on the idiosyncratic component of total stock return volatility is substantial. Thus, this finding indicates that the idiosyncratic volatility is positively related to the R&D investments.

The Hausman test score for the S&P-100 ensures that fixed effects model is more appropriate than the random effects model since the p value is significant. The test result together with the p value is given under:

Hausman test = 12.42

Prob > chi2 = 0.0061

Likewise, the UK scenario, the influence of R&D investments on firm specific risk or idiosyncratic volatility is positive in the US context. This means the effect of R&D investments on the idiosyncratic component of total volatility is notable among the leading US firms. Moreover, firm size is inversely related and significant at less than 1% level. However, leverage is also negatively significant at the 5% level for the S&P-100. This result is different from that of the FTSE-100 case. The negative impact of leverage in the US context infers that the presence of debt financing produces extensive positive signaling effect for the large-cap firms to reduce the idiosyncratic volatility. Stata generated regression outputs are placed in the Appendix.

5.0: Conclusion

It is easy to understand that R&D activities and required investments are very specific to a firm that actually involves them. Thus, the study is based on the concept of idiosyncratic volatility to find the impact of firm-specific investment on firm-specific volatility. Based on the firms under the two indexes that invest in R&D, this study presents the evidence that idiosyncratic volatility is positively associated with the R&D investment intensity. After controlling for leverage and firm size, the study regresses idiosyncratic volatility on R&D intensity. The finding of the study adds to the extant literature by offering R&D intensity as an important determinant to idiosyncratic stock return volatility.

This research has broad implication for the finance managers who should work on maintaining effectual communication policy to decrease extreme informational asymmetry concerning R&D activities. The management of R&D specific information with caution is highly advised. The study also has influences on investors' risk calculation, investment analysis and portfolio management decisions since higher level of idiosyncratic volatility is responsible for massive unpredictability of investment value. Future research can examine the nexus between R&D intensity and the valuation of derivative instruments. Also, the influence of several key firm characteristics on idiosyncratic risk can be appraised.

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Appendix

Effects of R&D on idiosyncratic volatility

UK:

```
. xtreg IDV RnD leverage Size, fe

Fixed-effects (within) regression               Number of obs      =       430
Group variable: companynum                      Number of groups   =        43

R-sq:                                           Obs per group:
     within  = 0.0499                                         min =        10
     between = 0.0083                                         avg =      10.0
     overall = 0.0004                                         max =        10

                                                F(3,384)           =      6.73
corr(u_i, Xb)  = -0.8554                        Prob > F           =    0.0002

------------------------------------------------------------------------------
         IDV |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         RnD |   .0605133   .0197311     3.07   0.002     .0217188    .0993079
    leverage |   .0069687   .0018504     3.77   0.000     .0033305     .010607
        Size |  -.0780841    .029552    -2.64   0.009     -.136188   -.0199801
       _cons |   1.365295   .4534373     3.01   0.003     .4737639    2.256825
-------------+----------------------------------------------------------------
     sigma_u |  .32988989
     sigma_e |  .22815563
         rho |   .6764406   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(42, 384) = 5.51                     Prob > F = 0.0000
```

USA:

```
. xtreg IDV RnD  Leverage Size , fe

Fixed-effects (within) regression               Number of obs      =       700
Group variable: companynum                      Number of groups   =        70

R-sq:                                           Obs per group:
     within  = 0.0509                                         min =        10
     between = 0.0868                                         avg =      10.0
     overall = 0.0474                                         max =        10

                                                F(3,627)           =     11.22
corr(u_i, Xb)  = -0.6631                        Prob > F           =    0.0000

------------------------------------------------------------------------------
         IDV |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         RnD |   .0126825   .0033218     3.82   0.000     .0061592    .0192057
    Leverage |  -.0014666   .0006994    -2.10   0.036    -.0028401   -.0000931
        Size |  -.0414618   .0121078    -3.42   0.001    -.0652386    -.017685
       _cons |   1.056876   .1998772     5.29   0.000     .6643661    1.449386
-------------+----------------------------------------------------------------
     sigma_u |   .1214343
     sigma_e |  .12265464
         rho |  .49500055   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(69, 627) = 5.32                     Prob > F = 0.0000
```

UK evidence of Idiosyncratic Volatility: Random vs. Fixed Effects

```
. hausman fixed

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed          .          Difference          S.E.
-------------+----------------------------------------------------------------
         RnD |    .0605133     .0011274        .0593859        .0187048
    Leverage |    .0069687     .0023882        .0045805        .0012769
        Size |   -.0780841    -.0218032       -.0562809        .0256079
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       17.18
                Prob>chi2 =      0.0006
```

US evidence of Idiosyncratic Volatility: Random vs. Fixed Effects

```
. hausman fixed

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
         RnD |    .0126825     .0038524        .0088301          .00304
    Leverage |   -.0014666    -.0008348       -.0006318        .0004311
        Size |   -.0414618    -.0296063       -.0118555        .0089616
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       12.42
                Prob>chi2 =      0.0061
```