Contents lists available at ScienceDirect

Technological Forecasting & Social Change

R&D investments and high-tech firms' stock return volatility

Sami Gharbi [a,b,1], Jean-Michel Sahut [c,*], Frédéric Teulon [c,2]

[a] University of Jendouba, Tunisia
[b] Cerege EA 1722-20, University of Poitiers, rue Guillaume VII le Troubadour, BP 639–86022 Poitiers, France
[c] IPAG Business School Paris, IPAG, 184 Boulevard Saint-Germain, 75006 Paris, France

ARTICLE INFO

ABSTRACT

The empirical evidence suggests that firms in high-tech industries exhibit high stock return volatility. In this paper, we conceive of the R&D investment intensity as a possible explanation for the stock volatility behavior in these industries. We suggest that R&D activities generate information asymmetry about the prospects of the firm and make its stock riskier. Relying on Panel data models, we investigate this relationship for French high-tech firms. We find out a strong positive relationship between stock return volatility and R&D investment intensity. This finding suggests that R&D intensive firms should implement an efficient information disclosure policy to reduce information asymmetry and to avoid excessive stock return volatility.

1. Introduction

Stock return volatility is a widely used measure of risk both in financial theory and practice. Stock return volatility is varying across time and firms. The investigation of the determinants of stock return volatility still forms an attractive research area.

Shiller [1] indicates that stock prices change so much that they cannot be merely explained by fluctuations in dividends or earnings. Schwert [2] finds little evidence that macroeconomic factors can explain stock market volatility movements.

Campbell, Lettau, Malkiel and Xu [3] provide formal empirical evidence that US idiosyncratic stock volatility has witnessed an upward trend. Kearney and Poti [4] confirm this finding for the European stock markets.

A large body of literature underlines the fact that idiosyncratic volatility is not only relevant in predicting stock market returns and volatility, but it is also priced. Goyal and Santa Clara [5] show that aggregate idiosyncratic volatility has a significant predictive power on the market's rate of return. Taylor [6] reports that the inclusion of idiosyncratic volatility improves the quality of market volatility predictions. Fu [7] documents a significant positive relationship between idiosyncratic volatility and expected returns. Stocks with an elevated idiosyncratic risk get a higher return than stocks with low idiosyncratic risk. Accordingly, the analysis of the features that affect idiosyncratic volatility enhances portfolio managers' and corporate directors' decisions.

In this paper, we propose the R&D investment as a possible determinant of stock return volatility. R&D expenditures have grown over the last decades. A firm invests in R&D activities and offers new products and services to differentiate itself and mitigate competition. Empirical results show that R&D investments, actually, create value for the firm. Some authors find a positive relationship between the stock returns or the market value of the US firms and the R&D intensity (Griliches [8], Hirschey and Weygandt [9], Sougiannis [10], Lev and Sougiannis [11]). Hall and Oriani [12] find the same results for France. Other authors report that corporate announcements about new R&D investment generate positive abnormal returns (Chan, Martin and Kensinger [13] and Eberhart, Maxwell and

* Corresponding author. Tel.: +33 6 51 03 24 88.
E-mail addresses: sami_gharbi@yahoo.fr (S. Gharbi), jmsahut@gmail.com (J.-M. Sahut), f.teulon@ipag.fr (F. Teulon).
[1] Tél.: +33 5 49 45 44 99.
[2] Tél.: +33 1 53 63 36 00.

Siddique [14]). However, many studies investigate the riskiness of R&D investments and find that R&D intensive firms are riskier than others (Chan, Lakonishok and Sougiannis [15], Kothari, Laguerre and Leone [16]).

This paper contributes to the literature by examining the relationship between R&D investment and stock return volatility. This analysis is performed within the context of the French market because as we know, this problem has been researched exclusively on the United States and studies on European markets barely exist. The analysis of the European context is useful for two reasons. First, US firms invest more in R&D than their European counterparts (Moncada-Paterno-Castello [17] and Moncada-Paterno-Castello, Ciupagea, Smith, Tubke and Tubbs [18]). Second, the R&D reporting reveals a difference between the USA and France. While US firms adopt R&D expensing, IAS-IFRS accounting rules, adopted by French firms, they differently cover research costs and development costs. Research costs are expensed, when development costs could be capitalized under certain conditions (IAS 38). Lantz and Sahut [19] point out that R&D capitalization seems to limit the information asymmetry between firms and exchange markets. Accordingly, the study of the relationship between stock volatility and R&D investment for non US firms, such as the French firms seems to be relevant due to these structural and accounting differences.

Stock volatility is positively related to the degree of information asymmetry encountering the firm's prospects and profits (Gennotte and Leland [20], Eden and Jovanovic [21]). R&D investments are expected to generate higher information asymmetry than tangible investments (Aboody and Lev [22]). We will test the hypothesis that stock volatility increases with the R&D investment intensity. We focus our analysis on high tech firms. These firms are R&D intensive and exhibit higher stock return volatility. Our empirical results provide strong evidence of the checked hypothesis, as for the US context. R&D investments make the firms' stocks riskier. The differences in accounting rules and investment behavior do not matter. These results contribute to the literature on the determinants of idiosyncratic volatility and also on the market valuation of R&D expenditures. The implications and recommendations will be discussed later.

The paper is organized as follows. Section 2 presents the theoretical background on stock volatility, information asymmetry and R&D. Section 3 provides empirical evidence on high tech firms. Section 4 develops the hypotheses. Section 5 presents and describes the sample and the research design. Section 6 evaluates the relationship between R&D and stock return volatility. The last section is devoted to concluding remarks and recommendations.

2. Theoretical background

2.1. Volatility and information asymmetry

Many studies investigate the nature of the relationship between stock volatility and asymmetric information. Theoretical models predict that stock return volatility increases as the degree of information asymmetry becomes higher. Gennotte and Leland [20] suggest that volatility excess and market crashes, such as the 1987 market crash, could be explained to a greater extent by the trades of uninformed

investors in a context of information asymmetry. Attanasio [23] argues that in the presence of asymmetric information and risk aversion, the stock prices tend to be more volatile than in full information environment. Eden and Jovanovic [21] formalize a theoretical model that explains the excessive volatility in financial markets by fluctuation of the amount of public information over time.

Since the level of information asymmetry cannot be directly measured, empirical studies use different proxies to approximate it. Analyst coverage, analyst prediction error, analysts' prediction dispersion, institutional ownership and bid ask spread are commonly used to measure the level of information asymmetry.

Sahut, Gharbi and Othmani Gharbi [24] corroborate theoretical models and find that stock volatility is negatively related to the institutional ownership and analysts' coverage for French firms. They find that analysts and institutional investors can mitigate the asymmetric information problem and reduce stock volatility.

2.2. R&D and information asymmetry

All types of projects generate some degree of asymmetric information between the managers (the insiders), who possess detailed information about the productivity of individual assets, and investors (outsiders) who have global and inaccurate information (Aboody and Lev [22]).

Hubbard [25] suggests that informational asymmetry related to R&D investments is particularly important. Alam and Walton [26] indicate that the level of information asymmetry between managers and shareholders is higher for the firms with R&D expenses compared to firms with no R&D investments. Blazenko [27] shows that managers have more knowledge about the state and the outcome of R&D activities compared to outsiders.

Boone and Raman [28] report a positive and significant relationship between R&D and bid ask spread. The bid ask spread increases with the level of information asymmetry.

R&D investments are associated with higher information asymmetry than physical and financial ones for many reasons.

First, R&D intensive firms have little incentive to disclose detailed information about their projects since they consider secrecy as an effective way to protect innovation and competitive advantage. Cohen, Nelson and Walsh [29] have examined the strategies of 1478 US R&D laboratories in protecting their innovations and found that the firm's secrecy is apparently much more practiced than patents, marketing and manufacturing complementary proficiencies.

Second, R&D projects are unique for the firms which conduct the projects. Aboody and Lev [22] (p 2750) explained: "The relative uniqueness of R&D investments makes it difficult for outsiders to learn about the productivity and value of a given firms' R&D from the performance and products of other firms in the industry thereby contributing to information asymmetry". The lack of organized markets for R&D projects worsens the problem.

Third, the accounting handling of R&D investment does not convey complete information about R&D valuation and profitability. Generally, R&D investments are never reported in the balance sheet but fully expensed in the profit and loss account, although, these expenditures can generate profits for several coming years and can be considered as assets (Oswald and Zarowin [30]). Franzen, Rodgers and Simin [31]

report that accounting based distress measures tend to misclassify solvent firms as their R&D spending increases.

Finally, Gu and Wang [32] present evidence that R&D expenditures are associated with higher analysts' prediction errors. Barth, Karzink and McNichols [33] found that analysts' earnings predictions dispersal is higher for R&D intensive firms than other firms. Therefore, disagreement among investors results from the level of information asymmetry.

R&D informational asymmetries adversely influence the financing decisions and the dividend policy. Firms encounter many difficulties to finance R&D projects (Alam and Walton [26], Hubbard [25]). Himmelberg and Petersen [34] ascertain that firms tend to rely on internal finance to cover R&D activities. Hall [35] finds that R&D intensive firms avoid using debt to finance R&D activities.

According to the signaling approach to the dividend policy, Barth and Kasznik [36] point out that R&D intensive firms tend to repurchase shares to convey information about the good quality of their projects.

2.3. R&D and firm's risks

The R&D uncertainty is substantially higher than that of tangible assets. R&D investments develop many types of firms' risks such as the risk of product failure, earnings variability, systematic risk, firms' bond risk, and stock return volatility.

First, Mansfield and Wagner [37] show that intangible investments have a higher probability of failure than tangible investments.

Second, Kothari, Laguerre and Leone [16] find that earnings variability of R&D investments is about three times higher than that on physical assets. Amir, Guan and Livne [38] conclude that R&D contributes more to the variability of subsequent operating income than physical assets. This result holds only in industries where R&D is relatively more intensive than physical capital.

Third, the empirical relationship between R&D and systematic risk yields contradictory results. Wedig [39] compares the systematic risk of R&D and non R&D firms and finds that R&D firms are riskier and that there is a significant systematic risk premium associated with R&D. Lantz and Sahut [19] provide evidence that the Beta is twice higher for companies with intensive investment in R&D compared to low R&D investing companies. Ho, Xu and Yap [40] report a positive association between R&D intensity and systemic risk whereas McAlister, Srinivasan and Kim [41] find that R&D and advertising lower the firm's systematic risk.

Fourth, Shi [42] examines the tradeoff between the future benefits from R&D and the riskiness from the perspective of bondholders. He finds that R&D investments are positively associated with bond default risk and bond risk premium and that the risks associated with R&D dominate the future benefits.

Fifth, Chan, Lakonishok and Sougiannis [15] find that R&D intensity is positively associated with the volatility of stock returns. They indicate that return volatility for R&D intensive firms is about 2.21 percent higher than the return volatility for firms with no R&D. In a more recent paper, Fung [43] provide empirical evidence that R&D and stock volatility are positively related in the US context. Chambers, Jennings and

Thompson II [44] find that excess returns are highly variable for firms with higher R&D levels. They define excess return as the difference between the realized return and the expected return from the Fama and French [45] model.

3. Empirical evidence in high-tech firms

3.1. Volatility of high-tech firms

Many empirical results show that high tech firms are more volatile than low-tech firms. Pastor and Veronesi [46,47] find that the "new economy" stocks (high tech) are more volatile than "old economy" stocks. They explain this result by the uncertainty about the success and the profitability of new technology.

Schwert [48] finds that NASDAQ, which is dominated by high-tech stocks, is more volatile than S&P index. Aggregate idiosyncratic volatility for Nasdaq firms is four times higher than that of NYSE/AMEX firms.

Nasdaq index increased from 329.84 in October 1990 to 5132.52 in March 2000, which represents about 1456.057 percent increase in less than a decade. Then, the index declined to reach 1108.48 in October 2002, which is a record of about 78.4 percent in less than three years (Tseng[49]).

Mazzucato and Tancioni [50] analyze volatility in different sectors and find that semi-conductors and electrical equipment in firms' stocks are more volatile than the S&P index benchmark.

3.2. R&D activities in high tech firms

During the last decades, high tech industries have been changing rapidly. Agarwal and Gort[51] report that the required time for an idea to be materialized in a viable product was 33 years in 1900 and 3.4 years in 1967–1987. Ittner and Larcker [52] corroborate this result in the computer and automobile industries. According to them, the intensity of the competition in these sectors is so significant that it readily justifies such findings.

R&D activities in high technology are particularly risky. Wetter [53] suggests that high tech firms face two additional risks compared to others firms. These firms have to create their own market for their new products. In addition, high tech firms may face the risk that their markets can be replaced by "alternate" technologies.

Grabowski and Vernon [54] examine the returns and risks in the pharmaceutical R&D and report that only 30 drugs out of 100 licensed drugs earned enough money to compensate for their R&D costs.

3.3. Asymmetric information in high-tech firms

The level of information asymmetry in high-tech firms is high due to the complexity and technicality of innovation. Liu [55] suggests that the innovation process in high technology industries consists of many stages with different sources of risk. Accordingly, investors tend to establish wrong predictions about the profitability of R&D projects.

Gu and Li [56] suggest that managers of high tech firms may amplify the asymmetric information problem. Owing to rude competition, managers are incited to hide key or detailed

information or to minimize the prospects of new products so as to discourage competition.

Many studies find that information asymmetry measures are more developed in high tech firms. Gu and Wang [32] find higher earnings prediction errors in high tech firms due to information complexity. Barron, Byard, Kile and Riedl [57] report that high tech firms are characterized by a low level of analysts' consensus because of the high R&D intensity.

Tasker [58] shows that high tech firms organize conference calls and provide additional information to compensate for the low informativeness of their financial statements. Dell'Acque, Perrini and Caselli [59] indicate that the use of conference calls may reduce idiosyncratic volatility for high tech firms.

3.4. The empirical relationship between R&D and stock volatility in high tech firms

The financial literature provides formal empirical evidences that R&D expenditures and volatility are positively associated in the high tech industries. Mazzucato and Tancioni [50] find that the higher the firm's R&D intensity, the higher the idiosyncratic risk is.

Xu [60] report a positive and significant association between R&D investment in the development of new drugs and stock price volatility of pharmaceutical firms.

Schwert [48] suggests growth options of high tech firms such as R&D and innovation can explain the higher volatility in NASDAQ. Cao, Simin, Zhao [61] corroborate this result and find that firms with high growth options are riskier.

3.5. Hypotheses development

R&D investments generate asymmetric information about their success probability, their nature, their prospects and their profits. Because stock return volatility increases with information asymmetry, we expect that it will increase with R&D investments. In this study, we distinguish between total stock volatility and idiosyncratic stock volatility. Thus, we develop our first hypothesis which states that:

Hypothesis (1). total stock return volatility is positively related to the R&D investment intensity.

R&D investments are specific to the firm. Therefore, we expect that R&D is more associated with the idiosyncratic component of total volatility. Thus, we develop our second hypothesis which states that:

Hypothesis (2). idiosyncratic stock volatility is positively related to the R&D investment intensity.

4. Sample and research design

4.1. Sample

Our initial sample includes the 162 French high-tech firms on Thomson Reuters that disclosed R&D expenses during the period 2002–2011. We focus on firms in high technology industries, namely information technology, electrical and electronic equipment and telecommunications. Firms in these sectors seem to have similar stock trading characteristics and

R&D behaviour. Our final sample consists of 1620 firms and yearly observations over the period 2002–2011.

4.2. Models and variables

Given that the data are in a panel, we must examine the pooled regression, the fixed effects model and the random effects model to choose the appropriate specification.

The pooled regression imposes the same constant α for all firms. The model can be presented as follows:

$$Y_{it} = \alpha + \beta'X_{it} + \varepsilon_{it} \tag{1}$$

Where Y_{it} is the dependent variable for firm i at time t, β' is a row vector of slope regressors, X_{it} is a column vector of explanatory variables for firm i at time t and ε_{it} is a residual error of firm i at time t.

The fixed effects model allows the constant to differ between firms but it is still time invariant. The coefficients α_i represent unobservable individual firm-specific effects. The model can be presented as follows:

$$Y_{it} = \alpha_i + \beta'X_{it} + \varepsilon_{it} \tag{2}$$

For the random effect model, the constant is a random variable that can be written in the following form:

$$\alpha_i = \alpha + u_i \tag{3}$$

The random effects model is presented as follows:

$$Y_{it} = \alpha + \beta'X_{it} + u_i + \varepsilon_{it} \tag{4}$$

To choose the appropriate specification, three tests have been conducted. The F-test examines the significance of the fixed effects. The Breush and Pagan [62] Lagrangian Multiplier examines the significance of the random effects. The Hausman test [63] compares the fixed and the random effects.

Our dependent variable relies on stock volatility. We consider two measures used separately. Total stock volatility (TV) is the annualized standard deviation of weekly returns for each year. Idiosyncratic stock volatility (IV) is the annualized standard deviation of weekly errors from the CAPM model for each year. We use weekly returns because they are supposed to contain less noise than daily returns, they eliminate the day of the week effect and they resolve the thin-trading problem. We make a logarithmic transformation on volatility measures to ensure that the stock volatility estimates are non-negative and to reduce both skewness and kurtosis of stock volatility distributions [5].

The total stock volatility measures the entire financial risk surrounding the firm's stock. It can be decomposed into systematic or market related risk and idiosyncratic or firm specific risk. We use this first measure to analyse the effect of R&D on firm financial risk.

R&D investments are specific to the firm that engages them. The use of idiosyncratic volatility will permit us to focus on the impact of specific firm investment on firm specific risk.

Following Chambers, Jennings and Thompson II [44] and Chan, Lakonishok and Sougiannis [15] among others, we

Table 1
Definition of used variables.

Variables	Abbreviations	Definitions
Total volatility	TV	Annualized standard deviation of weekly returns
Idiosyncratic volatility	IV R&D	Annualized standard deviation of weekly errors from the CAPM model
R&D intensity	SIZE	Ratio of R&D expenses to sales
Size Leverage	LEVERAGE	Natural logarithm of market capitalization Ratio of total debts to total assets

Table 3
Pearson correlation coefficients.

	Ln(TV)	Ln(IV)	R&D	Leverage	Size
Ln(TV)	1				
Ln(IV)	0.947***	1			
R&D	0.216***	0.214***	1		
Leverage	0.058	0.018	−0.083**	1	
Size	−0.293	−0.426***	−0.088**	0.169***	1

Note: Asterisks indicate significance at the 1% (***), 5% (**) and 10% (*) levels in a two-tail test.

5. Empirical results

Table 3 exposes Pearson correlations of volatility measures, R&D intensity and control variables. Total and idiosyncratic volatilities and R&D intensity are positively correlated, which in indicates that stock volatility increases with R&D intensity.

Along with previous research studies, volatility measures and size are negatively correlated. However, the correlations between volatility measures and leverage are insignificant. Both volatility measures are significantly and positively correlated with correlation coefficients at about 0.947.

The correlations between independent variables are not sufficiently large to cause multicollinearity problems.

Table 4 presents the results on the relationship between total volatility and R&D intensity. F-test shows that fixed effects are significant since F-statistic is significant at a 1% level. The large value of the Breush–Pagan Lagrangian Multiplier confirms the significance of the random effects. To choose the appropriate specification, the Hausman test is conducted. The Hausman test statistic is significant at 1% level so the fixed effects model is preferred to the random effects model.

Table 5 presents the results about the relationship between idiosyncratic volatility and R&D. According to the specification tests' results, the fixed effects specification is also preferable.

In the model with total stock volatility, the estimated coefficient of R&D is 0.393. It is positive and significant at the 1% level. The adjusted R-squared is 51.3%. Supporting H1, this result suggests that R&D intensity significantly increases the total stock volatility. This result corroborates Chan, Lakonishok and Sougiannis [15] and Fung [43] who document a positive relationship between total stock volatility and R&D intensity in the U.S. context.

In the model with idiosyncratic volatility, the estimated coefficient is 0.422. It is positive and significant at the 1% level. This finding supports H2 and suggests that idiosyncratic volatility is positively related to R&D intensity. The adjusted

make use of the ratio of R&D expenses applied to sales in order to measure R&D intensity.

Control variables, size and leverage are widely accepted as determinants of stock volatility. On the one hand, Christie [64] finds that the stock volatility increases with the leverage. The firm's debt financing affects its future cash flows through interest payment and increases the probability of payment default. On the other hand, smaller firms exhibit higher volatility and asymmetric information because financial analysts have little incentive to cover their activities and prospects (Bhushan [65]).

Size is measured by the logarithm of market capitalisation and leverage is measured by the margin between the ratio of total debt and total assets. Stock returns, market capitalization, R&D expenses, sales and leverage ratio are obtained from Thomson Reuters database. In order to reduce the effects of outliers on our results, we winsorize all the variables at both upper and lower levels at 1% of their distribution. Table 1 presents the variables' definitions and abbreviations.

4.3. Descriptive statistics

Table 2 reveals the following remarks: the volatility measures are high. They are averaging 49.1% and 46.9% for total volatility and idiosyncratic volatility respectively. Volatility measures have high skewness and high kurtosis. Logarithm transformation reduces both skewness and kurtosis. The distributions of the transformed variables are much closer to the normal distribution.

R&D intensity is relatively high for high tech industries firms. Firms invest on average 10.7% of their sales on R&D. The standard deviation of this variable is also high, measured at 19.2%. The R&D intensity is variable over time and across firms.

Table 2
Descriptive statistics.

Variable	Mean	Median	Sd.	Min.	Max.	Skewness	Kurtosis
TV	0.491	0.421	0.293	0.068	1.842	2.061	8.830
Ln(TV)	−0.854	−0.864	0.536	−2.688	0.611	−0.057	3.939
IV	0.469	0.388	0.295	0.066	1.785	2.044	8.438
Ln(IV)	−0.917	−0.945	0.561	−2.711	0.579	0.035	3.592
R&D	0.107	0.059	0.192	0.000	1.66	5.841	44.486
Leverage	0.168	0.122	0.172	0.000	0.973	1.577	6.294
Size	18.075	17.515	2.347	11.063	24.321	0.727	3.060

Note: See Table 1 for variable definitions.

Table 4
Effects of R&D intensity on the stock total volatility (ln(TV)).

Independent variables	Pooled model	Fixed effects model	Random effects model
Constant	0.064	2.762***	0.665***
	(0.464)	(6.097)	(2.930)
R&D	0.544***	0.393***	0.388***
	(6.095)	(2.833)	(3.615)
Leverage	0.398***	0.299***	0.376***
	(3.761)	(2.114)	(3.128)
Size	−0.058***	−0.202***	−0.091***
	(−7.833)	(−8.325)	(−7.452)
Adj-R^2	0.140	0.513	0.094
F-statistic	5.744		
Breush–Pagan LM test	208.57		
Hausman test	27.95		

Notes: The numbers in the parentheses are standard errors. Asterisks indicate significance at the 1% (***), 5% (**) and 10% (*) levels.

R-squared is 0.569. These statistics are better than those of the total stock volatility model. R&D activities are specific to the firm in which they are practiced and they further influence the idiosyncratic component of stock return volatility.

The results of control variables are consistent with theoretical predictions as well as previous empirical studies. Size is negatively significant, in accordance with the asymmetric information explanation provided by Bhushan [65] who suggests that analysts do not thoroughly cover small firms and that these companies exhibit higher information asymmetry. Leverage is positively significant, which matches the positive relationship documented in Christie [64] with a U.S. sample. Leverage makes firms stocks riskier.

6. Conclusion

The purpose of this paper is to examine the impact of R&D investments on the stock return volatility in a European context, namely, France. The previous studies focused on the U.S. context where a positive relationship has been found. There are at least two major differences between U.S. and French firms in dealing with R&D activities. First, U.S. firms invest more in R&D. Second, U.S. firms expense R&D while French firms expense research costs and capitalise development costs.

Table 5
Effects of R&D intensity on the stock idiosyncratic volatility (ln(IV)).

Independent variables	Pooled model	Fixed effects model	Random effects model
Constant	0.596***	2.568***	1.055***
	(4.272)	(5.709)	(4.570)
R&D	0.508***	0.422***	0.385***
	(5.683)	(3.066)	(3.565)
Leverage	0.354***	0.360**	0.374***
	(3.338)	(2.566)	(3.105)
Size	−0.090***	−0.195***	−0.116***
	(−12.126)	(−8.153)	(−9.312)
Adj-R^2	0.223	0.569	0.130
F-statistic	5.984		
Breush Pagan LM test	229.32		
Hausman test	27.959		

Notes: The numbers in the parentheses are standard errors. Asterisks indicate significance at the 1% (***), 5% (**) and 10% (*) levels.

With a sample of French firms that invest in R&D activities, we provide evidence that total stock volatility and idiosyncratic volatility are positively related to the R&D intensity. R&D activities increase the degree of information asymmetry about the firm's prospects and profits and they also make the firm's stock more volatile.

This finding contributes to the existent literature in two ways. First, R&D intensity should be considered as a determinant of stock volatility. The growth of R&D in the last decades could be considered as one plausible explanation of the upward trend in idiosyncratic volatility that many authors tried to explain since the seminal work of Campbell, Lettau, Malkiel and Xu [3]. Second, the difference in R&D reporting between U.S.A. and France does not affect the relationship between R&D and stock volatility. R&D investment makes the firm's stock riskier under expensing or capitalizing policies.

This research has implications for corporate managers who should implement an efficient communication policy that can reduce information asymmetry about R&D investment. Corporate managers should disclose information that reduces uncertainty about the product's success probability and the expected profits.

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Sami GHARBI is University of Jendouba, Tunisia & CEREGE EA 1722 - University of Poitiers, France Sahut Gharbi is preparing a PhD in Finance at the University of Poitiers under the supervision of Professor Jean-Michel Sahut. In particular, he analyses the link between stock volatility and R&D politics of firms. He is also a lecturer in Finance at the University of Jendouba. Sami Gharbi can be contacted at: sami_gharbi@yahoo.fr

Jean-Michel SAHUT is a IPAG Business School (Paris), France & CEREGE EA 1722 - University of Poitiers, France Jean-Michel Sahut is Professor at IPAG Paris. He teaches Corporate Finance, Venture Capital, Financial Accounting and Management for engineering and management students. Previously, he was a Professor at HEG Geneva (Ch), Associate Dean for Research at Amiens School of Management (Fr), Professor of Finance at Telecom & Management Paris Sud (Fr) and director of the RESFIN Laboratory. He has published more than sixty articles about finance, financial accounting, governance, management of technologies in international peer review journals and five books. Jean-Michel Sahut can be contacted at: jmsahut@gmail.com

Frédéric TEULON IPAG Business School (Paris), France Frédéric Teulon is a Professor of Economics and director of IPAG LAB (Paris). He has published more than fourteen books about economics and sociology problems. Frédéric Teulon can be contacted at: f.teulon@ipaf.fr