How Much Does Innovation Capability Matter for Firm Performance? A Variance Decomposition Analysis

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In this paper, I examined the extent of how much innovation capability Æ research and development investments matter in explaining the heterogeneity of firm performance Æ profitability. I explored this question using variance decomposition analysis among 1.078 distinct firms operating in 48 industries, headquartered across 40 different jurisdictions over eighteen years period (2004-2021). I first replicated previous studies using variance decomposition methodology in the empirical context, then I amplified research and development investments as an innovation capability determinant of firm performance in my empirical analysis. My results indicate that innovation capability explains a significant amount of variance in the operating profit margins of firms. A detailed analysis of decomposed variance suggests that innovation capability Æ research and development investments explain roughly 2 percent of the total variance in firm performance Æ profitability, and 3.21 percent of the estimated variance coefficient. Additionally, my study concludes that firm-, industry-, country-, and time- effects explain the variance of the firm performance Æ profitability by 37 percent, 11 percent, 4 percent, and 1 percent respectively. Therefore, the internal business context (business unit effects, and research and development investments) together matter more than the external business context (industry, country, time) in the determination of firm performance Æ profitability.

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A Variance Decomposition Analysis

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Abstract:

In this paper, I examined the extent of how much innovation capability – research and development investments matter in explaining the heterogeneity of firm performance – profitability. I explored this question using variance decomposition analysis among 1.078 distinct firms operating in 48 industries, headquartered across 40 different jurisdictions over eighteen years period (2004-2021). I first replicated previous studies using variance decomposition methodology in the empirical context, then I amplified research and development investments as an innovation capability determinant of firm performance in my empirical analysis. My results indicate that innovation capability explains a significant amount of variance in the operating profit margins of firms. A detailed analysis of decomposed variance suggests that innovation capability – research and development investments explain roughly 2 percent of the total variance in firm performance – profitability, and 3.21 percent of the estimated variance coefficient. Additionally, my study concludes that firm-, industry-, country-, and time- effects explain the variance of the firm performance – profitability by 37 percent, 11 percent, 4 percent, and 1 percent respectively. Therefore, the internal business context (business unit effects, and research and development investments) together matter more than the external business context (industry, country, time) in the determination of firm performance – profitability.

Key Words:

| Innovation Capability **|** Research and Development Investments **|** Firm Performance **|** Performance Heterogeneity **|** Variance Decomposition Analysis **|**

INTRODUCTION

The essential objective of strategic management research is to understand how firms can outperform their competition while attaining sustained competitive advantage. Partial thanks to innovation capabilities, such as research and development investments for instance, innovation scholars widely believe that firms enhance their chances to achieve sustained competitive advantage (Distanont & Khongmalai, 2020). Thus, research and development investments promise firms to become a market-share leaders, or market leaders defining the future of the industry (Moldoveanu & Narayandas, 2019). For this reason, innovation capabilities are crucial to firms, their management, as well as stakeholders far beyond shareholders because competitiveness and innovation are complementary (Alvarez & Barney, 2001).

In the past 25 years, scholars in strategy research have been greatly investigating the industry, country, time, and firm-specific effects in understanding firm performance (Bamiatzi et al., 2016; McGahan & Porter, 1997, 2002; Misangyi et al., 2006; Roquebert et al., 1996; Rumelt, 1991; Schmalensee, 1985). Also, it is widely believed that there is a positive link between the innovation capability of a firm and firm performance (Calantone et al., 2002). Nonetheless, the role of research and development investments in the profitability of firms besides industry, country, business unit, and time effects remains a missing link. Thus, my study quantitatively examined the extent of how much research and development investments matter in firm performance – profitability, besides analysing the relative significance of industry, country, business unit, and time specific effects in firm performance.

My study explores, for the first time, the effects of research and development investments together with industry, country, firm, and time on the profitability of firms. Throughout this paper, the term *"firm"* refers to the company, business segment, or business unit incorporated as a separate entity – a subsidiary. The term *"innovation capability"* refers to research and development investments which underlines the proposition of Ottaviano (2004) as *"the ability of an organization to successfully innovate on a sustained basis".* The phrase *"firm performance"* refers to the profitability of a distinct firm, whereas, profitability was measured through operating profit margin as ratio of operational profits to total revenues from sales, operating, financing, and joint venture activities.

It is widely debated that firm specific effects either at the corporate or business unit level matter the most in understanding firm performance. However, much less is known about the relative significance of innovation capability – research and development investments of firms in their performance efforts such as the profitability proxy of operating profit margin.

Thus, my study intends to identify whether, and how much innovation capability, industry, country, firm, and time matter *vis-à-vis* firm performance, while addressing the following research questions. Firstly, what business environment context is the most influential determinant in firm performance? Secondly, how much do research and development investments affect firm performance? To address these questions, I adopted variance decomposition methodology to quantitatively measure the increment of ordinary and adjusted coefficient of determination in firm performance caused by the sequential order of research and development investments, industry-, country-, firm-, and time-effects.

My study proceeds as follows. In the second section, I reviewed innovation capability literature, and predecessors using variance decomposition analysis in explaining the heterogeneity in firm performance – profitability. Then, in the third section, I described the variance decomposition methodology applied in this paper. The fourth section highlights the comprehensive process of dealing with the data set. Then I revisited empirical evidence of research and development investment, industry, country, business unit, and year effects importance in explaining firm performance. I conclude my study with key findings while setting out recommendations for further research. Finally, my paper appends relevant descriptive statistics from the analysis.

LITERATURE REVIEW

Innovation Capability

The evolution of research into innovation capability doesn't have a long history. Only in the past decade, there has been an increasing amount of literature on the relationship between innovation capability and firm performance. The construct of innovation capability in the business context was first articulated in the title by Calantone et al. (2002). We can only polemicize whether, and if at all their work was a starting point for later emerging studies.

The existing literature on innovation capability in a business context is comprehensive about the definition of innovation capability and its concept. In the recent review of innovation capabilities, Narcizo et al. (2017) highlight the need to conceptualize the definition of innovation capability in organizations. Their study discovered that the term *"innovation capability"* in the business and management context was used in previous research with 19 different definitions. In my paper, the definition of innovation capability reflects on the research and development investments while underlines the proposition of Ottaviano (2004) as *"the ability of an organization to successfully innovate on a sustained basis".*

Thus far, innovation capability research recognized two ultimate approaches to measuring innovation capability. While some scholars have criticized the input-output perspective to measure innovation capability (Ab Rahman et al., 2015), others used indirect measures reflecting either inputs or outputs which can be perceived subjectively. It is because inputs such as research and development investments, intensity, expenditures on new product development, external knowledge, machinery etcetera, are industry-dependent (Mendoza-Silva, 2021). Based on the Frascati Manual 2015 to measure scientific, technological, and innovation activities, OECD (2015) suggests that the business enterprise sector accounts for the largest proportion of research and development expenditures.

Hence, carrying out this study with an explicit focus on research and development expenditures in the business enterprises sector has more practical significance than focusing on government, higher education, non-governmental and non-profit organisations.

Much of the previous innovation studies have focused on the downstream of innovation capability in firms – the output perspective such as patents or share of new products (Foss & Saebi, 2017; Geissdoerfer et al., 2018; Saunila, 2020). My paper aims to contribute to innovation studies with a focus on upstream innovation of innovation capability in firms – the input perspective such as the research and development investments because it is logically inconceivable that firms could produce innovative outputs without innovation inputs.

Antecedents of variance decomposition in firm performance

Schmalensee (1985) was among the first pioneers to employ variance decomposition analysis to examine the relative importance of firm, industry, and market share differences in the profitability of manufacturing firms based in the United States. His work incorporated U.S. Federal Trade Commission (FTC) data in the year 1975 and included 1,775 observations on business units operated by 456 firms. His empirical findings provide evidence for the existence of industry effects equalling roughly 20 percent of the variation in business-unit profits, whereas, firm effects did not exist, and market share effect had a negligible (0.62 percent) impact on the variation in business-unit profits. Schmalensee (1985) concluded that market share effects coupled with industry effects had a negative correlation.

Comparatively, Rumelt (1991) amplified the approach taken by Schmalensee (1985) through the extension of the FTC data for then all available years from 1974 until 1977. His approach examined the relative significance of firm (corporation, and business unit), industry, and year differences in the profitability of U.S. manufacturing firms. His final data set consisted of 6,931 observations on business units operated by 457 firms. Conversely to Schmalensee

(1985), Rumelt (1991) reported significantly different findings. The largest and most stable effects were caused by business units equalling approximately 46 percent variation in the business-unit profits, followed by industry effects (9 percent – 16 percent), and corporate effects (1 percent – 2 percent). While Schmalensee (1985) reported that firm effects did not exist, Rumelt (1991) found out that the most important source of profitability – firm performance was firm-specific, while industry membership was less important than the business unit itself.

The next study on the importance of firm and industry effects in the profitability among U.S. manufacturing firms was extended by Roquebert et al. (1996). In their work authors extracted data from the COMPUSTAT database for a greater period between 1985 and 1991 to compare results with the FTC data used by Schmalensee (1985) and Rumelt (1991). The final data set consisted of 16,596 observations on business units operated by 6,873 firms. While empirical evidence of Roquebert et al. (1996) produced a relatively high degree of support with Rumelt (1991) in regards to firm effects (55 percent) rather than industry effects (12.5 percent variation in the business-unit profits), their work suggests substantial distinction of business-unit and corporate effects. Rumelt (1991) reported corporate effects accounting for 1 percent - 2 percent of the variation in business-unit profits, whereas, Roquebert et al. (1996) reported 17.9 percent corporate effects, and 37.1 percent business-unit effects equalling 55 percent of firm effects variation in business-unit profits.

McGahan and Porter (1997) conducted a similar study but significantly extended the period of observations. In their study authors compiled data from the COMPUSTAT database for 14 years from 1981 up to 1994, while analysing all sectors including manufacturing and excluding the financial sector. Their finally screened dataset consisted of 58,132 observations out of which 18,298 accounted for US manufacturing firms, which made their study the largest concerning the amount of examined firms (7,003 corporations). The authors concluded that the most important source of firm performance were business unit effects[1] (31.71 percent), followed by industry effects (18.68 percent), corporate parent effects (4.33 percent), and year effects (2.39 percent) in the variation of firm profits.

Five years later, McGahan and Porter (2002) advanced their previous study using the same COMPUSTAT data, however this time with 72,742 observations for the same 14 years period. Oppositely to their previous study, rather than reporting results from the variance decomposition analysis through the components of variance (COV or CVA) method, the authors explicitly used the nested analysis of variance (nested ANOVA) method. The percentage of total variance for year, industry, corporate, and business unit effects in the advanced study concluded that these effects explained 0.8 percent, 9.6 percent, 12.0 percent, and 37.7 percent respectively of variance in business unit profits. This evidence produced a high degree of agreement with Roquebert et al. (1996) confirming that firm performance depends on (1) business unit effects, (2) corporate parent effects, (3) industry effects, and (4) year effects.

Nine years later, Misangyi et al. (2006) performed variance decomposition analysis using the multilevel approach to estimate the relative importance of firm effects sub-divided among corporate parents, business units, industry, and year effects. He used the same database COMPUSTAT as McGahan and Porter (2002), but with an increased timeframe equalling sixteen years period with 10,633 observations. His model incorporated time effects at the first level, and therefore accounted for the largest proportion of effects explaining 47.8 percent of the total variance in firm performance. Followingly business unit effects of 36.6 percent, industry effects of 7.6 percent, corporation effects of 7.2 percent, and year effects with 0.8

[1] Business unit effects (articulated as business segment effects in their terminology).

percent of the explained total variance of firm performance. Nevertheless, the multilevel approach is incomparable with the previous studies using linear models.

Previous studies reported decomposed variance by two techniques. The first technique (components of variance) was expressed by the percent of variance accounted for (Bamiatzi et al., 2016; McGahan & Porter, 1997; Misangyi et al., 2006; Roquebert et al., 1996; Rumelt, 1991; Schmalensee, 1985). Oppositely, the second technique (nested analysis of variance) was the percentage for explanation (estimate) of variance. In my study, I adopt both techniques to make obtained results comparable with previous studies (Bamiatzi et al., 2016; McGahan & Porter, 1997, 2002; Misangyi et al., 2006; Rumelt, 1991).

It is important to realise that previous research (Bamiatzi et al., 2016; McGahan & Porter, 1997, 2002; Roquebert et al., 1996; Rumelt, 1991; Schmalensee, 1985) using the variance decomposition method focused on evaluating the firm performance through the proxy of profitability measure as the average ratio of operating profit to total identifiable assets, expressed as return on assets (ROA). Bamiatzi et al. (2016) suggest that the utilization of alternative firm performance measures could provide further evidence for the firm, industry, country and year effects. Therefore, rather than a replication of the previous profitability return of firm performance measure, I adopt operating profit margin ratio of the operational profits to total revenues as a proxy of profitability measure representing firm performance.

In the empirical analysis, by decomposing the variance into firm, industry, and country specific factors, I will be able to quantify importance of individual factors which are in line with the strategy tripod framework developed by Peng et al. (2009). Strategy tripod explains firm performance via three pods representing industry-based competition (industry effects), institutional conditions and transitions (country effects), and firm-specific resources and capabilities (firm effects). However, the extent of how much specific effects explain variation in firm performance complemented by research and development investments can extend research by having a measurement for the firm-specific capabilities such as the innovation capability.

METHODOLOGY

I approached methodology by utilising a variance decomposition analysis to explain the variance of explanatory variables consisting of research and development investments, industry-, country-, business unit-, and year-specific effects in the response variable (firm performance).

The variance decomposition method has been markedly applied by scholars within the field of strategy research (Bamiatzi et al., 2016; McGahan & Porter, 1997, 2002; Misangyi et al., 2006; Roquebert et al., 1996; Rumelt, 1991; Schmalensee, 1985; Sohl et al., 2020; Zaefarian et al., 2022). Similarly to preceding studies, I examine the amount of variance in the response variable explained by year-, country-, industry-, and business unit effects. However, my study distinguishes from the previous studies using the variance decomposition method because I include additional explanatory variable representing research and development investments.

To quantitatively examine the extent to which research and development investments, in addition to the respective effects matter in firm performance, my analysis relies on the model expressed in the equation [1]:

[1]

$$\boldsymbol{FP_{i,c,f,y} = \mu + \alpha_{rd} + \beta_i + \gamma_c + \delta_f + \varepsilon_y + \epsilon_{i,c,f,y}}$$

The left-hand side of the equation represents the fractional response variable $FP_{i,c,f,y}$ which denotes firm performance (FP), of a business unit (f), in a year (y), headquartered in a country (c), operating in the industry (i). Firm performance was measured through the operating profit margin ratio of the operational profits to total revenues[2] (see equation 3).

[2] Total revenues = revenues from sales, operating, investing, financing, and joint venture activities.

The right-hand side stipulates explanatory variables. The first term on the right-hand side μ represents the constant corresponding to the grand mean of operating profit margin. The second term α_{rd} indicates the *research & development investments effects* reflecting the innovation capability as proposed by Hong et al. (2015). The second term β_i depicts the *industry effects* in which a specific business unit operates. The third term γ_c represents *country-specific effects* where a particular business unit is headquartered. The fourth term δ_f indicates *business unit effects*. The fifth term ε_y denotes *year effects*. The final term of the left-hand side is the residual error variation.

The fixed effect model in my study allows for heterogeneity – individuality among respective business units by allowing each firm to have own intercept value. The heterogeneity across time of firm performance, and research and development investments is portrayed in Appendix 1.

All of the fixed effects are characterised by the group of dummy variables. The sizes of individual effects are determined as incremental changes in the coefficient of determination of the model defined in equation 1. Consequently, the extent of a particular effect is controlled by measuring how much each block of explanatory variables $(\alpha_{rd}, \beta_i, \gamma_c, \delta_f, \varepsilon_y)$ contributes to explaining variance in the ordinary coefficient of determination (R^2).

I also assume that the random process of sequential inclusion of explanatory variables into the model does not correlate among individual effects. I then decompose the variance of firm performance – profitability using equation [2]:

[2]

$$\boldsymbol{\sigma_R^2 = \sigma_{rd}^2 + \sigma_i^2 + \sigma_c^2 + \sigma_f^2 + \sigma_y^2 + \sigma_\epsilon^2}$$

The left-hand side of this equation indicates the overall variance that is explained by the ordinary coefficient of determination (R^2) developed from equation 1. The right-hand side of the equation represents variances of the respective explanatory variables. In the decomposition process, I observe the change in increment of explanatory power by each explanatory variable added to the null model which consisted of the response variable explained in equation 4 and constant. The observation of increment in the explanatory power from the respective effects was conducted in the sequence of research and development investments followed by industry, then country, then business unit (firm), and time – year effects.

The response variable of my study represents firm performance measured through profitability of operating profit margin using equation [3]:

[3]

$$\boldsymbol{FP_{i^x,c^x,f^x,y^x} = \sum \left(\frac{OP_{i^x,c^x,f^x,y^x}}{TR_{i^x,c^x,f^x,y^x}} \right) \times 100}$$

The firm performance of a respective business-unit f^x, for a particular year y^x, headquartered in the country c^x, and operating within the industry i^x is expressed through the proxy of profitability margin. The profitability indicator reflects the operating profit margin, calculated as the sum of the multiplicative fraction between operational profits (OP) to total revenues (TR). Both operational profits and total revenues consisted of a common unit (€ mil.), therefore, I did not have to convert OP and TR to a joint unit - currency.

The null model in my study was developed using equation [4]:

[4]

$$\boldsymbol{FP_{i,c,f,y} = \mu}$$

The left-hand side of the null model indicates firm performance developed in equation 3, whereas, the right-hand side indicates the constant of the grand mean obtained from the firm performance. This approach allows me to measure respective effects caused by explanatory variables to the ordinary coefficient of determination (R^2) in equation 1.

Finally, I quantified the proportion of the estimated variances from each explanatory variable of the model using equation [5]:

[5]

$$\boldsymbol{\sigma_M^2 = \frac{\sigma_{rd}^2}{\sigma_R^2} + \frac{\sigma_i^2}{\sigma_R^2} + \frac{\sigma_c^2}{\sigma_R^2} + \frac{\sigma_y^2}{\sigma_R^2} + \frac{\sigma_\epsilon^2}{\sigma_R^2}}$$

The left-hand side of equation 5 indicates the total variances of the model. The right-hand side represents individual contributions (percentage) of the estimated variances to the developed model in equation 2.

DATA

To empirically examine the relative significance of research and development investments in explaining variation in firm performance, I needed data with annual information about firms' research and development expenditures, besides information about industries, and countries. I developed unbalanced panel data set from the cross-sectional open access data of the European Commission's Joint Research Centre (JRC) project titled The Economics of Industrial Research & Innovation (IRI) – EU Industrial Research & Development Investment Scoreboard (EC, 2022).

The EU Industrial Research & Development Investment Scoreboard includes the annual economic and financial information of the globally leading corporate research and development investors. The original dataset is established based on secondary data from each firm's annual report. For each firm, the EU Industrial Research & Development Investment Scoreboard classifies the country and region of origin based on the location of the firm's headquarters. The classification of the regions in the data set comprises five regions: (1) US - United States, (2) EU - European Union, (3) China, (4) Japan, and (5) RoW - Rest of the World. Further, classification is extended through the firm's industry. In total, the data set recognizes 61 different industries. For each firm, the data set contains research and development -expenditures, -intensity, total revenues, operational profits, capital expenditures, number of employees, and market capitalization. I used EU Industrial Research & Development Investment Scoreboard data for the year 2004-2021.

Before I screened the EU Industrial Research & Development Investment Scoreboard data, I had to manually verify every primary and unique key in the original cross-sectional data set to transpose time series into panel data. The original data set contained errors concerning the names of the firms without bearing updates of names after rebranding, intentional name changes, mergers, acquisitions, or typos. In addition, the same applied to industry, country, and region classification. Upon verification of data, I assigned each firm, industry, country, and region a unique key identifier. Before I screened my unbalanced panel data set, the EU Industrial Research & Development Investment Scoreboard contained 31.100 observations, whereas, each record described a single business unit investing in research and development between 2004 and 2021.

From the initial data set, I dropped 805 business units that did not contain information on total revenues or operational profits. It is because I calculated firm performance through profitability measure as the average ratio in percent of operational profits (€mil.) to total revenues (€mil.)[3]. Bamiatzi et al. (2016) suggested to utilising alternative firm performance measures including profitability measures such as the one used in this study, rather than return on assets (ROA) or Tobin's Q which has been used extensively. Hence, my study promises to lend further evidence for the previous studies using the variance decomposition method.

Then, I excluded 1.264 business units operating within aerospace, defence, and finance[4] industries following McGahan and Porter (1997), whereas, the profitability of these industries was incomparable with the remaining industries. In addition to that, I excluded leisure & hotels, toys, transport, and utilities – other industries because the sample size within these industries had less than 5 business units which could not provide significant evidence for the industry effects.

Followingly, a total of 20.227 business units were excluded with a market share of less than 1 percent and greater than 80 percent. The exclusion of business units with a market share less than 1 percent was previously used by Schmalensee (1985), whereas, the exclusion of business units with a market share greater than 80 percent dropped out 10 business units that

[3] Firm performance = Profitability, Operating Profit Margin as Operational Profits / Total Revenues.
[4] Finance industries = Banks, Equity Investment Instruments, Financial Services, Life Insurance, Nonequity Investment Instruments, Nonlife Insurance, Other Financials, Real Estate Investments & Services.

are parallel to monopolies because I can not determine their industry effects from their business unit-specific effects. Lastly, I dropped out 195 business units with single-year appearances because they could represent extreme cases, for instance.

The transformation and screening procedure from the cross-sectional data into balanced panel data set resulted in 8.608 observations, with an average of 478 business units per year from 2004 to 2021. The screened panel data set consists of 1.078 distinct business units that operate in 48 industries, and are headquartered across 41 different jurisdictions. On average, a singular business unit posts 7.99 years of data[5] including lagged information[6], while McGahan and Porter (1997) reported 5.70, therefore, my study allows me to observed effects over longer period.

There are certainly valid advantages and drawbacks of the EU Industrial Research & Development Investment Scoreboard data. In the first place, the data set covers a relatively long period (18 years). This allows me to measure the influence of research and development investments over various stages of the business life cycle besides examining the time – year effects on firm performance. For this reason, my results are less sensitive to abnormalities because the period incorporated in my analysis is sufficiently long. A second advantage of the EU Industrial Research & Development Investment Scoreboard data is that it covers a broader variety of industries.

The major drawback of the EU Industrial Research & Development Investment Scoreboard data is its population size. Between 2021 and 2014 the original data set consisted of 2.500 observations on leading corporate research and development investors globally for each year respectively, whereas, between 2013 and 2004 the size of observations is significantly lesser. For 2013, the original data set contained 2.000 observations, for 2012 - 1.500

[5] Calculated as total observations divided by the number of distinct business units (8.608 / 1.078).
[6] Lagged information: first observation of each business unit was excluded from the empirical analysis.

observations, for 2011 - 1.400 observations, between 2010 and 2006 – 1.000 observations, for 2005 – 700 observations, and for 2004 the original data set contained only 500 observations.

Another defect in the original data set is missing values. Not all business units contained information on either operational profits or total revenues. Therefore, I was unable to calculate their firm performance using the proxy of profitability measure as the operating profit margin.

The table 1 describes screened European Commission's Joint Research Centre (JRC) data by year, and region. The grand mean of firm performance for 18 years was 9.93% with a variance of 172.46 percent.

Table 1. Screened European Commission's Joint Research Centre (JRC) Data

(A) By year

Year	**No.**	**Mean R&D**	**Mean FP[a]**	**Median FP[a]**	**Year**	**No.**	**Mean R&D**	**Mean FP[a]**	**Median FP[a]**
2004	248	632.13	9.39	7.76	2013	500	735.26	9.36	8.03
2005	293	568.04	10.58	9.00	2014	511	685.46	10.32	7.83
2006	451	463.54	10.42	9.06	2015	520	761.81	10.88	8.23
2007	470	442.54	11.15	9.66	2016	512	881.30	8.83	8.16
2008	486	439.40	10.89	10.03	2017	522	937.64	9.97	8.28
2009	475	531.96	7.71	8.42	2018	529	900.38	11.04	9.06
2010	480	487.56	6.99	6.13	2019	542	999.59	10.82	9.03
2011	551	648.08	10.84	9.05	2020	543	1082.53	9.87	7.71
2012	474	766.64	10.69	8.55	2021	501	1144.27	8.78	6.93

(B) By region

Region	**No.**	**Mean R&D**	**Median R&D**	**Mean FP[a]**	**Median FP[a]**
China	600	608.13	194.76	8.37	6.38
EU	1467	795.26	158.00	8.93	8.49
Japan	2101	608.27	195.77	6.34	5.52
RoW[b]	1789	556.30	130.59	11.25	8.39
USA	2651	977.06	228.15	12.81	13.07
TOTAL	**8608**	**742.90**	**179.61**	**9.93**	**8.42**

[a] **Firm Performance =** Ratio in percent (%) of operational profits (€ mil.) to total revenues (€ mil.)

[b] Rest of the World

EMPIRICAL RESULTS

In this section, I present my estimates of equation 2 and equation 5 through variance decomposition method supplemented by analysis of variance results developed from equation 1. Table 2 portrays analysis of variance results obtained from equation 2 and 5.

The reported results in Table 2 highlight that 55.09 percent of the total variance in firm performance is explained by the developed model in equation 1. The error term of 44.91 percent implies that firm performance – profitability is liable to various sources of distress in the market, and industry where a particular business unit operates.

Table 2. Variance decomposition results developed from equation [2] and [5].

Groups	% of total variance – equation [2]	% of the estimated variances – equation [5]
Null model	0	0
R&D Investments	1.77	3.21
Industry	10.90	19.79
Country	4.23	7.67
Business unit	37.39	67.87
Year	0.80	1.45
Full Model	***55.09***	***Total σ_M^2 = 100***
Error	***44.91***	
Total σ_R^2	**100**	

Roughly 2 percent of the total variance in firm performance is explained by the effects of the ***research and development investments***. The effects of research and development investments are significant at the 0.000 level. Moreover, I discovered that the ratio of variance for research and development investment effects increases markedly by adding explanatory variables to equation 1. This result implies that firm performance is weakly affected by the amount of research and development investments.

Almost 11 percent of the total variance in firm performance is characterised by ***industry effects***. These effects are significant at the 0.000 level. However, the ratio of variance for industry effects increases at the stable level by adding additional explanatory variables to equation 1. Comparing these results with previous studies, Sohl et al. (2020), Misangyi et al. (2006) and Rumelt (1991) estimated that industry membership is less important in explaining firm performance. All authors reported industry effects equalling less than 9 percent of the total variance. On the other side, comparable estimates to my results were reported by McGahan and Porter (2002), whereas, their model estimation concluded that industry effects equal to 10.30 percent impact on firm performance. However, my study differs noticeably in regards to the industry effects, instead of market share as a proxy of the industry effects, I developed dummy variables for each industry and examined industry effects through the membership within a particular industry.

More than 4 percent of the total variance in firm performance was explained by ***country effects***. The country effects are significant at 0.000 level. This result implies that firm performance is less dispersed to the country of origin (headquarters) than to the industry in which a particular firm operates. Moreover, I discovered that the ratio of variance for country effects increased marginally by adding the explanatory variable of time effects to equation 1. Oppositely to previous studies, my results highlight less importance of the country in explaining firm performance – profitability than Sohl et al. (2020) and Makino et al. (2004), which reported 7.8 percent, and 5.5 percent respectively of variance in firm's profitability.

The highest explanation of the total variance in firm performance was attributable to the ***business unit effects***. Stable effects of the business unit accounted for about 37.4 percent in the explanation of the total variance of 55.09 percent. My estimate of the business unit effects indicates that more than 67 percent of the model is explained by business units – firms themselves. This result implies that business unit effects are higher than half of the total variance explained by the model.

Moreover, my estimate of the business unit effects on the profitability of firms is median point to the previous studies. McGahan and Porter (1997) and Misangyi et al. (2006) reported business unit effects of 35.1 and 36.6 percent respectively, whereas, Rumelt (1991) and McGahan and Porter (2002) estimated business unit effects of 41.3 and 37.7 percent respectively. For this reason, my study is the central point to the previous empirical assessments, however, my results are distinct in the examination of business units separately without their corporate parent effects.

Lastly, less than 1 percent of the total variance in firm performance was explained by time – ***year effects***. Comparatively to the previous effects, year effects are significant at 0.000 level. My estimate for year effects provided the least explanation in the firm performance – profitability because the coefficient of determination increased only by 0.8 percent by adding the explanatory variable of the year. This result implies that firm performance is least affected by time, whereas, the most influence is explained by business units themselves. My estimate of year effects corresponds with Misangyi et al. (2006) which reported the same amount of variance explained by time. However, in comparison with the previous studies, the estimate of 0.8 percent variance of year effects is still greater than reported by Makino et al. (2004), Sohl et al. (2020), and McGahan and Porter (2002) using components of variance technique.

Figure 1 summarises the results of the decomposed variance in Table 2. The upper part of the figure illustrates how much respective effects increase explanatory power in the coefficient of determination (R^2), and adjusted coefficient of determination (adj. R^2) of the developed model in equation 1. The bottom part of the figure illustrates how much respective effects explain the total variance of the model developed considering ordinary R^2 – coefficient of determination of the model developed in equation 2.

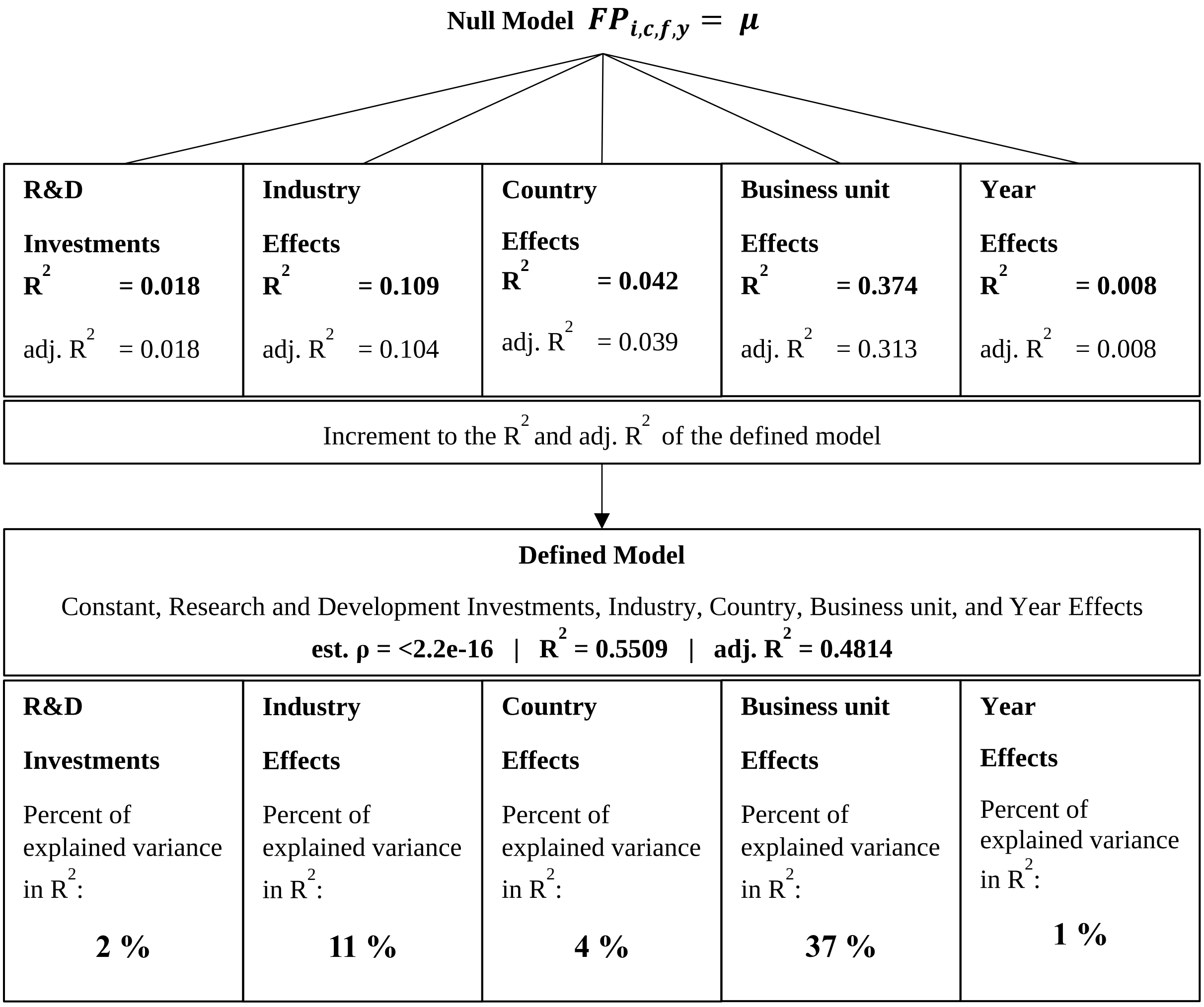

Figure 1. Decomposed analysis of variance on the equation 1 and equation 2.

Table 3 portrays an individual increment to the explanatory power (coefficient of determination) by specific effects in the ordinary R^2 and adjusted R^2 from equation 1. It is obvious from the variance decomposition reported in Table 2 that the coefficient of determination and adjusted coefficient of determination in the Null model ($FP_{i,c,f,y} = \mu$) were determined to be set at the null level. I calculated the increment to the explanatory power of the ordinary coefficient of determination and the adjusted coefficient of determination in the following order: first – research and development investments, second – industry effects, third – country effects, fourth – business unit effects, fifth – time (year) effects.

Table 3. Increment to the explanatory power (R^2 and adj. R^2) by individual effects.

Groups	Δ in Ordinary R^2	Δ in Adjusted R^2
Null model[a]	0	0
R&D Investments[b]	0.018	0.018
Industry[c]	0.109	0.104
Country[d]	0.042	0.039
Business unit[e]	0.374	0.313
Year[f]	0.008	0.008
Full Model	***0.551***	***0.481***
Error	***0.449***	***0.519***
Total σ^2	**100**	**100**

Notes.

[a] Null model = Firm performance ~ μ Constant.
[b] Increment in model of R&D Investments over Null model.
[c] Increment in model of R&D Investments and Industry effects over Null model.
[d] Increment in model of R&D Investments, Industry, and Country effects over Null model.
[e] Increment in model of R&D Investments, Industry, Country, and Business unit effects over Null model.
[f] Increment in model of R&D Investments, Industry, Country, Business unit, and Year effects over Null model.

Research and development investments add less than 2 percent to the ordinary and adjusted coefficient of determination. Industry effects attribute 10.9 percent to the ordinary coefficient of determination, and 10.4 percent to the adjusted coefficient of determination. Country effects contribute to the ordinary coefficient of determination with 4.2 percent, and 3.9 percent to the adjusted coefficient of determination. Followingly, business unit effects append 37.4 and 31.3 percent for the ordinary, and adjusted coefficient of determination respectively. Finally, time – year effects attribute with the least proportion to the ordinary and adjusted coefficient of determination, equalling 0.8 percent of explained variance.

The significance levels, the ratio of mean squares, and the degree of freedom for the individual effects observed in equation 1 are enclosed in Appendix 2.

CONCLUSIONS

The main objective of this paper was to quantitatively examine the extent to which the innovation capability of firms matters in their performance - profitability. I measured the innovation capability of the firms through the indirect measure of input perspective – research and development investments. The firm performance in this study was determined as a profitability measure through operating profit margin calculated as a percentual ratio of operational profits to total revenues. For the empirical assessment, I used open access, cross-sectional data set from the European Commission.

The purpose of this paper was to extend previous studies using variance decomposition methodology in the field of strategic management research. Up to the present time, scholars focused on the quintessential questions in the economics of strategy, trying to understand the relative importance of country, industry, time, and firm effects on profitability of firms. My study extends their understanding of business profits explained through innovation capability of firms such as investments to research and development on the business unit level.

The results of my study have identified variation in firm performance – profitability through research and development investment, industry effects, country effects, business unit effects, and time – year effects as follows. Firstly, research and development investments account for roughly 2 percent of the total variance in firm performance - profitability. Secondly, industry effects explained approximately 11 percent of the total variance in the profitability of firms. Thirdly, country effects attributed to the explanation of firm profitability with a 4 percent variance in the coefficient of determination. Fourthly, business unit effects had the largest contribution to the explanation of firm performance – profitability accounting for 37 percent of the total variance, and 67 percent in the explanation of the model. Finally, time classified as year effects in this study accounted for less than 1 percent of the total variance in the explanation of firm performance – profitability.

Given the data set and methods applied in my study, I was able to fully answer research questions. In fact, I have identified that context of the internal business environment is the most influential determinant in firm performance - profitability. Secondly, the effect of innovation capability – research and development investments has very mild influence on the firm performance – profitability determination. My results support previous studies regarding the importance of explanation in firm profitability in the following order. The most important determinant of the firm performance is explained by business unit effects, followed by industry effects, country effects, research and development investments, and lastly, time – year effects.

Nevertheless, the external validity of my results is subjective. The sample size of my study consisted of 8.608 observations[7] representing 1.078 distinct business units operating in 48 industries, headquartered across 40 jurisdictions throughout 18 years, from 2004 to 2021.

Finally, I have not addressed the question of whether, and how much industry, country, business unit, and year effects have relative importance in the innovation capability of firms – research and development investments. In particular, I suggest repeating the variance decomposition analysis, however, further research might explore the response variable of the innovation capability, rather than the profitability of the firm. For instance, how much industry-, country-, business unit-, and time-effects matter in innovation capability output such as the number of patents, the share of new products, or input such as research and development investments, expenditure on machinery, external knowledge, new product development etcetera. Thus, I hope that further research can extend an understanding of firm performance through my contribution to explaining the role of research and development investments in firms' profitability.

[7] Including lagged information before conducting analysis following equation 1.

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Appendix 1.

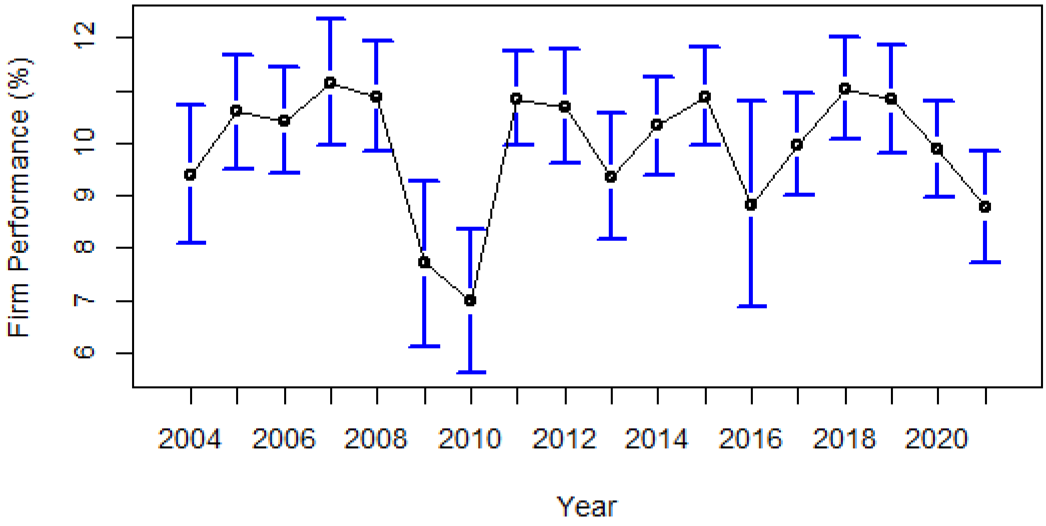

Figure 2. Firm Performance Heterogeneity Across Time.

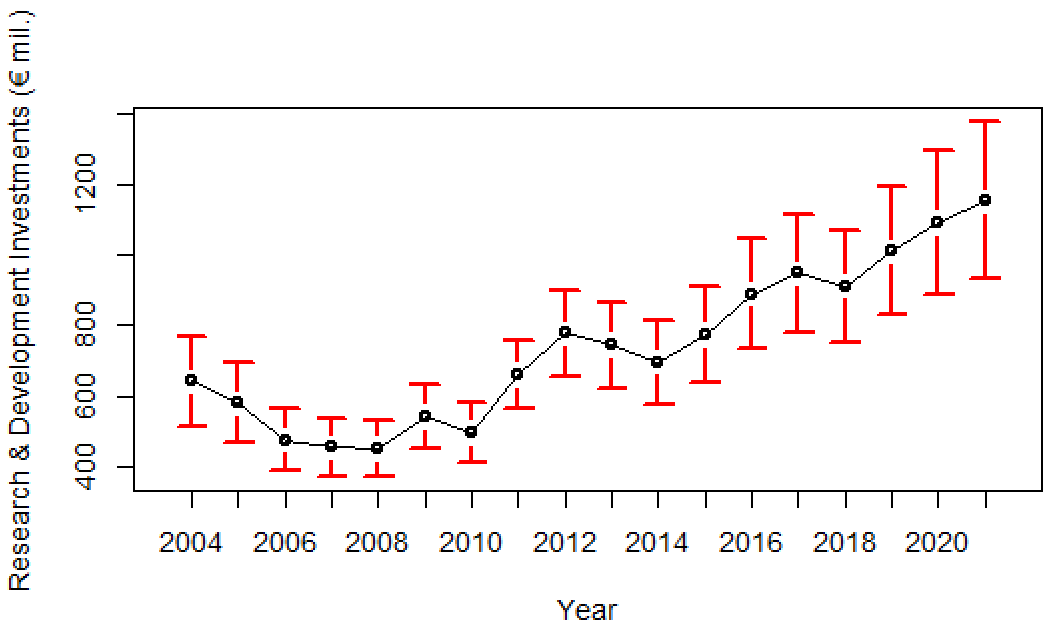

Figure 3. Research and Development Investments Heterogeneity Across Time.

Appendix 2.

Table 4. Analysis of variance results developed from equation [1]

Groups[b]	df	Sum. Sq.	Mean Sq.	F-value		Pr(>F)	Signif. Codes[a]
R&D Investments	1	26327	26327.2	294.38	<	2.2e-16	***
Industry	47	161751	3441.5	38.48	<	2.2e-16	***
Country	39	62753	1609.0	17.99	<	2.2e-16	***
Business unit	1049	555014	529.1	5.92	<	2.2e-16	***
Year	17	11899	699.9	7.83	<	2.2e-16	***
Residuals	7454	666644	89.4				

[a] **Significance codes:** '***' = 0, '**' = 0.001, '*' = 0.01, '.' = 0.05, ' ' = 0.1, blank = 1.

[b] **Summary of the model**: Residual standard error: 9.457 on 7454 degrees of freedom.
Multiple R-squared: 0.5509
Adjusted R-squared: 0.4814
F-statistic: 7.93 on 1153 and 7454 DF, ρ-value: < 2.2e-16.

Appendix 3.

R Code used for the Analysis

 # [1] IMPORTING MODULES: PACKAGES FOR DATA PROCESSING - ANALYSIS

```
# Import packages
library(readxl)
library(stargazer)
library(plm)
library(ggplot2)
library(tidyverse)
library(ggthemes)
library(xtable)
```

 # [2] DATA PRE-PROCESSING

```
# Loading cleaned data
rddata <- read_excel("Analysis - Clean Sample.xlsx")
View(rddata)
```

 # [3] DESCRIPTIVE STATISTICS

```
# Creating descriptive statistics
rddata %>% group_by(Year) %>% summarise(mean(FPP), median(FPP), mean(RD),
median(RD))
rddata %>% count(Year)
rddata$FPP %>% mean()
rddata$FPP %>% var()
rddata$RD %>% mean()
rddata$RD %>% var()
constant <- rddata$FPP %>% mean()
rddata <- rddata %>% mutate(constant)
d1 <- rddata %>% count(Year)
```

```
d2 <- rddata %>% group_by(Year) %>% summarise(mean(FPP), median(FPP), mean(RD),
median(RD))

destab <- data.frame(c(d1, d2[c("mean(FPP)","median(FPP)","mean(RD)","median(RD)")]))

dtout <- xtable(destab)

print(dtout, type='html', file="./descriptives.html")

# Descriptives by Region

rddata %>% group_by(Region) %>% summarise(mean(FPP), median(FPP), mean(RD),
median(RD))

rddata %>% count(Region)

dr1 <- rddata %>% count(Region)

dr2 <- rddata %>% group_by(Region) %>% summarise(mean(FPP), median(FPP),
mean(RD), median(RD))

destabr <- data.frame(c(dr1,
dr2[c("mean(FPP)","median(FPP)","mean(RD)","median(RD)")]))

dtoutr <- xtable(destabr)

print(dtoutr, type='html', file="./descriptivesreg.html")
```

 # [4] NULL MODEL + EFFECTS

```
# Conducting regression analysis

m1 <- lm(FPP~constant, data = rddata)

summary(m1)

anova(m1)

m2 <- lm(FPP~constant+RD, data = rddata)

summary(m2)

anova(m2)

m3 <- lm(FPP~constant+RD+factor(Industry), data = rddata)

summary(m3)

anova(m3)

m4 <- lm(FPP~constant+RD+factor(Industry)+factor(Country), data = rddata)

summary(m4)

anova(m4)
```

```
m5 <- lm(FPP~constant+RD+factor(Industry)+factor(Country)+factor(Corr_Name_ID), data = rddata)

summary(m5)

anova(m5)

m6 <-lm(FPP~constant+RD+factor(Industry)+factor(Country)+
        factor(Corr_Name_ID)+factor(Year), data = rddata)

summary(m6)

anova(m6)
```

 # [5] UNOBSERVED HETEROGENEITY

```
# Plotting heterogeneity across time of firm performance and research and development investments

plotmeans(FPP ~ Year, main="Heterogeneity across time", data = rddata,
    ylab = "Firm Performance (%)", n.label = F, barcol = "blue", barwidth=2)

plotmeans(RD + FPP ~ Year, data = rddata,
    ylab = "Research & Development Investments (€ mil.)", n.label = F, barcol = "red",
    barwidth=2)
```