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Determinants of Firms' Capital Structure and Liquidity

High R&D Intensity Industries in the European Union

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Master in Business Economics and Competition

Supervisor:
Full Professor Joaquim José dos Santos Ramalho,
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BUSINESS
SCHOOL

Department of Economics

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Resumo

O que determina a Estrutura de Capital e Liquidez das empresas intensivas em I&D? Este documento pretende responder a esta questão para a União Europeia. Os resultados mostram que alguns dos determinantes clássicos se aplicam a estas empresas, mas também requerem condições especiais em fases críticas, por não poderem recorrer tanto a dívida, mas também por tipicamente deterem mais ativos líquidos, consequências de atividades mais arriscadas e assimetrias de informação. Com base nestes resultados, são revistas algumas das políticas existentes da UE para apoio a estas empresas e são feitas sugestões dirigidas aos investimentos não-I&D de empresas intensivas em I&D, atribuição de mais recursos através de instrumentos financeiros de capital, um novo modelo para servir de garante para estas empresas e aumentar esforços na proteção ao investidor em alguns países.

Palavras-chave: Estrutura de capital, Liquidez financeira das empresas, Indústrias I&D, Política económica empresarial.
JEL Codes: G32, L53

Abstract

What determines the Capital Structure and Liquidity of R&D intensive companies? This study aims to answer this for the European Union. The results show that some of the classical determinants apply to these companies, but also that they require special conditions in order to overcome critical phases, for not being able to resort as much to debt and typically holding more liquid assets, consequences of riskier activities and information asymmetries. Based on these results, some of the existing EU policies for assisting such companies are revised and suggestions are made concerning more attention on non-R&D investments from R&D intensive companies, allocation of more resources through equity financial instruments, a new model to serve as guarantor for these companies, and increasing efforts in investor protection in some countries.

Keywords: Capital structure, Corporate financial liquidity, R&D industries, Enterprise policy.
JEL Codes: G32, L53

Contents

List of Acronyms

AUS	Australia
AUT	Austria
BEL	Belgium
BGR	Bulgaria
BRA	Brazil
CAN	Canada
CHN	China
CYP	Cyprus
CZE	Czech Republic
DEU	Germany
DNK	Denmark
ECB	European Central Bank
EIB	European Investment Bank
ERDF	European Regional Development Fund
ESMA	European Securities and Markets Authority
ESP	Spain
EST	Estonia
EU	European Union
FIN	Finland
FRA	France
GDP	Gross Domestic Product
GRB/UK	United Kingdom
GRC	Greece
GVA	Gross Value Added
HA1 - H10.1	Hypothesis A1 - Hypothesis A10.1
HB1 - HB7	Hypothesis B1 - Hypothesis B7
HRV	Croatia
HUN	Hungary
IMF	International Monetary Fund
IND	India
IRL	Ireland
ISIC	International Standard Industrial Classification

ITA	Italy
JPN	Japan
KOR	South Korea
LTU	Lithuania
LUX	Luxembourg
LVA	Latvia
MLT	Malta
M&M	Modigliani and Miller
NLD	Netherlands
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
POL	Poland
PRT	Portugal
R&D	Research and Development
ROA	Return on Assets
ROU	Romania
RUS	Russia
SME	Small and Medium-sized Enterprises
SVK	Slovakia
SVN	Slovenia
SWE	Sweden
TFP	Total Factor Productivity
ULC	Unit Labour Costs
UN	United Nations
USA/US	United States of America
VIF	Variance Inflation Factor
ZAF	South Africa

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1. Introduction

"*Society can only move forward as fast as it innovates. It can only provide lasting prosperity if it makes the most of the knowledge, entrepreneurial spirit and productivity of its people*." (Commission Communication "A renewed European Agenda for Research and Innovation - Europe's chance to shape its future"; contribution to the Informal EU Leaders' meeting on innovation in Sofia on 16 May 2018)

For the most developed economies, the path for greater growth and sustainability necessarily involves constant investment in R&D and innovation, with its importance confirmed and widely accepted as a critical catalyst for such, through direct effects on technological leadership, spillovers across sectors and other externalities such as higher qualified job creation and high value-added. EU's innovation policy reflects deep knowledge of economics behind R&D. It disposes of significant financial resources to improve its performance on this matter, by supporting R&D and innovative projects, especially from SMEs, directly and indirectly.

The question that remains is: Can EU's policy aiming investment in R&D and innovation be improved? – To answer this, determinants of these firms' leverage and liquidity are analysed, and plausible explanations for the results obtained are discussed by confrontation with the main theories of capital structure and cash holdings, and also with the endogenous growth theory, the main theory that addresses endogenously determined technological change as a driver for sustainable economic growth. The ultimate goal of this dissertation is thus searching for possible financial obstacles standing in the way of the success of companies from the most R&D intensive sectors, and based on these, a review of EU policies designed to improve R&D and innovation performance.

Therefore, the majority of the research carried out in this dissertation consists in understanding what distinguishes firms from High R&D intensive industries from the remaining concerning financing options and needs, since literature suggests they have characteristics that make them harder to finance relatively to others and are often impossible to collateralise, consequences of riskier activities, information asymmetries and holding few tangible assets, as their investments are tendentially more of intangible nature.

Inference results confirm that R&D intensive companies indeed have special financing needs, resorting less to leverage and holding more liquid assets, at the same time proving that most classical determinants are relevant for both leverage and liquidity, with financial assistance being particularly relevant during the first years of existence, for SMEs, after

financial crises, and when located in less developed economies (which are expected to have less developed financial systems).

These results are the foundations for revising EU policies assisting the most innovative industries, concluding that despite these companies being already financially assisted with different instruments - through grants, loans, equity and guarantees - better results can be achieved in efficiency of R&D in terms of economic results by strengthening financial assistance in critical phases and when investing in non-R&D assets such as operational and production equipment.

Because these firms are subject to innovation-induced liquidity risk, this research also highlights the importance of shareholder protection - where different countries within the EU show great differences - and which seem to be positively related to liquidity, meaning the lack of it results in overinvestment due to agency problems, reducing firms' performance.

The structure of this dissertation is the following. Chapter 2 reviews the literature on capital structure, liquidity and the endogenous growth theory. Chapter 3 describes the entire methodologic process: the specific topics to be addressed; the research hypotheses to be tested; the definition of the industries within the scope of the analysis; the variables and the estimation methods used. Chapter 4 presents the empirical results obtained, first with descriptive statistics to identify trends or elements that might stand out, then using inference to test the research hypotheses. Chapter 5 uses the results and conclusions obtained when testing the research hypotheses to review EU policies supporting firms from R&D intensive industries. Finally, chapter 6 summarizes the main conclusions obtained from the research.

2. Literature Review

To better understand R&D investment, it is necessary to review prior investigation related to the topic in both spectrums to be addressed in this study: micro- and macro-economic performance. At a micro-level, it is essential to review prior conclusions on capital structure and liquidity, first regarding firms in general, then focusing on the ones that share characteristics of the firms that are in the scope of this study. Therefore, there will be revised theories around optimal capital structures, costs and benefits of debt and liquidity, and what distinguishes firms with higher R&D intensity from the rest.

At a macro level, revision should be made to the evolutionary economic theory started by Schumpeter (1942), which points to knowledge development, capital expenditure and technical change as the major sources of productivity and job creation which leads to the economic growth and competitiveness. Later on, these will serve as arguments that provide justification for policies aiming at raising the level and efficiency of R&D relying on the assumption of close links between R&D expenditure and performance at both micro and macro-economic levels.

2.1. Main Theories of Capital Structure

Firm's capital structure is defined by the amount of equity and debt in its composition. It gained particular relevance as a topic of debate when Modigliani and Miller (1958) suggested that a company's market value would be independent of its capital structure, meaning that there is not an optimal capital structure.

Modigliani and Miller's theory[1] is developed in the context of perfect capital markets and is based on assumptions such as: no taxes; no bankruptcy costs and no transaction costs; companies only issue two types of securities (risk-free debt and equity); all companies belong to the same risk class; all investors have access to the same information and managers' main objective is to maximize shareholders' wealth.

Assuming these, the model reaches the following conclusions: (i) if the investor decides to loan, then the decision to finance the company cannot affect its value, or else it would be irrational; (ii) the value creation of each company depends solely on the income generated by its assets and the average cost of capital of the company will be similar to companies with identical risk; (iii) the weighted average cost of capital and the value of the enterprise are

[1] Often referred as MM or M&M theory.

independent of its capital structure, i.e. the value of an indebted firm should be equal to that of a debt free one, i.e. assuming that the capital market is perfect the capital structure has no influence on the value of the company.

Essentially, based on these assumptions (efficient market), it was demonstrated that identical companies had the same value regardless of whether their financing was through equity or debt.

There were several criticisms made to this theory and with them came other explanatory theories of capital structure. The main one is based on the argument that taxes provide evident incentive for firms to use debt, so Kraus and Litzenberger (1973) proposed the classic perspective of trade-off theory, in which companies choose their optimal capital structure, the one that maximizes their value, based on the trade-off between the benefits and costs of debt-to-equity financing. Among the benefits of debt financing are the tax advantages[2], but also the disciplinary role of debt. As for costs, there are bankruptcy costs and agency costs between shareholders and bondholders.

Since then, the trade-off theory has become the most prevalent theory of capital structure with numerous contributions. DeAngelo and Masulis (1980) acknowledge that as debt grows in proportion in firm's Capital Structure, there is a growing chance that its results will drop until they are not able to benefit from the tax shield effect, which implies that firms will not be indebted indefinitely. It was also suggested by these authors that there are other types of tax shields (non-debt) such as the effects of tax deduction when firms invest, through depreciation and investment tax credits, which may act as a substitute to the debt tax shield and imply a market equilibrium with a unique optimal leverage decision.

Myers (1977) explains that, despite the existence of an optimal capital structure for each firm, there are restrictions these may face when trying to achieve such objective. These restrictions are related to their capacity to borrow capital, which involves assets being offered as collateral for loans. Thus, Myers states that firms with a greater proportion of tangible assets have more ease in higher debt levels since this type of asset suits better as a guarantee for lenders in the case of liquidation. It is also mentioned by this author that firms' decisions are rational, based on (i) risk and (ii) future opportunities. Decisions based on risk not only imply avoiding high debt ratios, and matching maturities, but also serve as signalling devices to investors about firms' business risk and profitability. Decisions based on future opportunities take in account that risky debt decreases the present market value of the firm by leading to a future strategy that

[2] Debt tax benefit (also referred as "tax shield"): costs with debt such as interests and other non-operating expenses associated have a negative impact on Earnings Before Tax (EBT), meaning less income will be subject to tax.

is suboptimal, or in other words, the cost of opportunity of obtaining a risky loan in the present, it is the fact that high-interest rates will restrain future investment possibilities.

Warner (1977) focus on the bankruptcy costs as a restrain firms face when increasing debt level. It is suggested by this author that a positive relationship between firms' dimension and debt level is expected since larger companies tend to have a greater diversification of their activities. This greater diversification of activities means that the company is less exposed to bankruptcy costs and, consequently, its probability of bankruptcy is reduced. Thus, larger companies tend to increase their debt levels as a result of the lower prospect of bankruptcy and also as a way of obtaining higher tax benefits from the tax deduction of interest.

Miller (1977) kept his original position on the matter, that a company's market value would be independent of its capital structure, stating that although he believes there are deadweight costs attached to debt, such as bankruptcy costs and agency costs, they are not significant when compared to the tax savings through debt or market value of the firm's securities. This still maintains the original M&M theory proposition as Miller defends an equilibrium with implications in personal taxes, meaning that tax disadvantage at the personal level will cancel tax advantages of debt at the corporate level.

Another important explanatory theory of capital structure is the agency costs theory introduced by Jensen and Meckling (1976), based on the analysis of the conflict of interests arising within companies' various agents. For Jensen and Meckling, the organization can be understood as a network of contracts, whether explicit or implicit, which set out the functions and define the rights and duties of all its stakeholders. From these relationships arise the "principal" and "agent" figures. The principal is who (at any hierarchical level or for the organization as a whole) sets a certain goal, while the "agent" is the one to whom the "principal" delegates decision-making power as a means of achieving the stated goal. Jensen and Meckling identify two types of conflicts between principals and agents: conflicts between shareholders (principal) and top managers (agent), and between creditors (principal) and shareholders (agent).

In order to measure the impact of conflicts, namely the impact on corporate capital structure, Jensen and Meckling introduced the variable "agency costs". Agency costs are composed of three elements: (i) the opportunity cost associated with wealth reduction when there are disagreements between shareholders and managers; (ii) control costs of managers' activities, such as audits and other types of controls; (iii) bankruptcy and restructuring costs of the company. These costs may be such that they directly influence the capital structure of companies and may compromise the creation of value for them.

According to Jensen and Meckling, the optimal capital structure is achieved by striking a balance between reducing bankruptcy costs and increasing the amount of debt. The latter, in addition to providing tax gains, also reduces conflicts of interest between managers and shareholders, since the flows generated by the operating activity will have to settle interest and debt amortization, leaving less free resources so that the managers can somehow use them personally.

Conflicts of interest between shareholders and creditors emerge from asset substitution. Sometimes shareholders are encouraged to exchange their assets for more competitive assets that will represent higher returns but have associated higher risk. When it comes to high-risk projects, lenders seek to prevent such exchange by predicting that the investment may not have the expected return and that the company may not be able to settle its debt to its creditors. This conflict of interest also creates an additional cost for lenders who will have to analyse whether the company has a track record of good projects and debt repayments, including through collecting and analysing information.

Jensen (1986) and Stulz (1990) argue that companies with slow growth and high cash flow should have higher debt levels as a way to avoid investment in projects with low or even negative profitability. Consequently, they also argue that the use of debt in these companies acts as a disciplinary and mitigating means of the conflict between shareholders and managers.

Therefore, according to the agency costs theory, there are two possible conflicts of interests pushing in opposite directions when it comes to capital structure: (i) shareholder-creditor and (ii) shareholder-manager. The conflict of interest between shareholders and debtholders will push firms towards less leverage, subsequently underinvestment and discarding profitable projects. In contrast, the conflict of interest between shareholders and managers will push firms towards higher debt levels as an effort to reduce agency costs of free cash flows at managers' disposal, or in other words, free cash flows are distributed as dividends and replaced by debt, restraining managers' possibilities for inefficiency or misbehaving.

When Harris and Raviv (1990) approached the issue, they also struggled with the conflict of interest between shareholders and managers. According to these authors, the conflict is caused by the disagreement between the parties on the company's liquidation decision, that is, while the managers want the continuity of the company, shareholders have a greater tendency for its liquidation. Thus, debt arises as a means of resolving such conflict, as it gives investors the right to demand liquidation of the company whenever cash flows do not reach reasonable levels. They also note that the higher a company's liquidation level, the higher its debt level and

market value; whereas companies offering high returns have associated high levels of debt; and that the use of debt is independent of the dimension of the company.

Diamond (1989) argues that a company's reputation can help to minimize the problem of asset substitution. According to the author, the better the history of compliance with the company's obligations, the lower the financing costs, the sooner the company will tend to invest in safe projects in such a way as not to undermine its good reputation.

As referred by Ramalho and da Silva (2009), the agency costs theory is often considered inclusive of the trade-off theory since it also focusses on the benefits and costs of debt.

The pecking order theory, initiated by Myers (1984) and Myers and Majluf (1984), is one of the best-known explanatory theories of capital structure. According to this theory, the capital structure of a company is not based on the optimal level of debt that maximizes the value of the company, but rather that it results from successive optimal decisions among the funding sources in a hierarchical manner, having as aim to minimize the costs of information asymmetry.

Due to information asymmetries, firm's shares may be incorrectly valued by the market (undervalued or overvalued). In this context, and in the event of an underestimation, if the company needs to resort to a capital increase to fund a new project, new shareholders will see their wealth increase by more than net present value (NPV). On the contrary, current shareholders will see a decrease in their wealth, because their assets were undervalued, which meant that they would contract capital at a higher interest rate than if their assets were properly valued. Based on a company's financing needs, asymmetric information will affect the choice of the preferred funding source to use. According to the pecking order hypothesis, firms rank the following choices: (i) Companies have a clear preference for self-financing over external financing; (ii) Faced with investment opportunities, companies are gradually adapting their pay-out ratios to avoid sudden changes; (iii) The need for stable dividend policy, coupled with unpredictable fluctuations in profitability and its investment opportunities, means that internally generated funds are higher than or less than the financing opportunities imposed by growth opportunities. If higher, the company repays debt and / or purchases marketable stocks; if they are inferior, it sells owned stocks; (iv) If external financing is required, companies start by resorting to debt; then, they may issue hybrid securities - such as convertible bonds - and only resort to issuing new shares as a last resort.

In short, the pecking order hypothesis is based above all on the assumption that there are anomalies in the capital markets, namely imperfect information (asymmetric rather than instantaneous).

Models testing the trade-off theory and the pecking order theory concluded that the later "has much greater time-series explanatory power than a static trade-off model" (Shyam-Sunder and Myers, 1999, p. 219), meaning that firms' external financing is driven by the internal financial needs rather than gradual adjusts towards an optimal debt ratio. Shyam-Sunder and Myers relate internal financial needs to investment opportunities[3], stating that firms with more investment opportunities need more external financing since they are more likely to outrun internally generated funds.

Petersen and Rajan (1994) argue that the firms' age is also related (negatively in this case) to external financing, i.e., since older companies tend to accumulate internally generated funds, they will require less debt, as to the opposing situation, younger firms will likely have more needs for external financing.

Specifying on corporate investments in research and development (R&D) and innovation, Hall et al. (2015) suggest that these gather a number of characteristics that makes it harder to finance relatively to other investments, since they are riskier, more uncertain, and hold consequences both for their equity financing – as investors discount uncertainty on stock markets – and for their debt financing – when collateralisation becomes more difficult or even impossible.

In addition, such corporate investments raise more problems of opportunistic behaviour, adverse selection and moral hazard caused by information asymmetry between firms and potential investors. Consequently, R&D intensive firms should mainly rely on their internally generated funds, as in the pecking order theory of Myers and Majluf (1984).

2.2. Theories Focusing on Liquidity

Cash and cash equivalents refer to the amount of funds immediately available to make payments, or assets that are easily convertible into cash such as short-term bonds with a maturity date not superior to three months, marketable securities and money market holdings. Combined, cash and cash equivalents are the most direct way to measure firms' liquidity, i.e., its ability to meet short-term obligations. The importance of efficient cash management and liquidity in general has also gained relevance as research topic, although it is more or less implicit in the main theories of capital structure.

[3] Shyam-Sunder and Myers state that the amount of investment opportunities for firms is positively related to their profitability.

One of the most noticeable hypotheses comes from the pecking order theory through the contribution of Myers and Majluf (1984), which concludes that there is a negative relationship between liquidity and debt since firms rather use internally generated funds. As previously referred, Shyam-Sunder and Myers' contribution, also from the pecking order theory, relates investment opportunities to the need of external financing, meaning that firms with more investment opportunities will be more likely to hold lower cash ratios.

If self-financing capacities exceed investment needs, firms tend to discard debt, create liquidity reserves, and if there is still capital, it is distributed in dividends. If there is a lack of capital, managers first use cash reserves they created earlier, then use debt and only resort to capital increases if necessary. As far as cash policy is concerned, this theory suggests that there is no optimum level as companies adjust their liquidity levels according to their investment needs.

The trade-off theory, coherently to the existence of an optimal capital structure, also claims for the existence of an optimal level of cash holdings, which is at the breakeven point where the marginal cost and benefit of holding cash are equal (Al-Najjar and Belghitar, 2011).

Al-Najjar and Belghitar (2011) point out the following benefits for firms holding cash, originally identified by Ferreira and Vilela (2004): (i) lower probability of financial distress as it serves as a reserve to deal with unpredicted losses and restrictions; (ii) cash holdings help firms in investment plans execution when facing limitations to raising funds; (iii) holding cash minimizes the costs of raising funds and liquidation costs if required.

Also, Opler et al. (1999), based on Keynes (1936), refers that benefits of cash holdings result from transaction cost and precautionary motives, supporting cash management practices in a trade-off theory perspective.

The precautionary motive, however, contradicts pecking order theory since it implies that there may not be a negative relation between cash holdings and debt as firms may hold cash to use only when there is not the possibility to use other financing sources.

The free cash flow theory, started by Jensen (1986), suggests that due to agency problems, managers may undertake actions that do not maximize shareholder welfare, at the expense of policies that fulfil their own interests and goals. Cash holdings are a source of free capital that allows managers to invest in projects without resorting to debt markets. This gives managers the freedom to invest in projects that may not bring shareholder value but improve their own well-being without the monitoring that would have existed if they had resorted to external financing. According to Opler et al. (1999), liquidity allows managers three ways to act for their own well-being. Firstly, cash holdings may exist for risk aversion reasons. Second,

liquidity retention allows managers to invest in projects to achieve their goals that would never be funded in the capital markets. Lastly, managers accumulate cash rather than paying dividends. According to the free cash flow theory, corporate liquidity allows managers to follow investment policies without the control and pressure of lenders to perform well. Not needing to provide markets with information about the real value of projects, it is possible for managers to use liquidity reserves to invest in unprofitable projects (Jensen, 1986).

According to Jensen (1986), in companies where managers' objectives are aligned with those of shareholders, lower liquidity levels are expected.

While Opler et al. (1999) found no significant evidence of the impact of agency costs on corporate cash policies, the study by Dittmar et al. (2003) found strong evidence that companies in countries where there is little shareholder protection have higher cash levels than countries with more effective protection mechanisms. This was also supported by later studies by Harford (1999), Faulkender and Wang (2006), Pinkowitz et al. (2006), Dittmar and Mahrt-Smith (2007), Harford et al. (2008) and Nikolov and Whited (2009).

Over time, some authors have argued for the influence of cash flow in the amount of cash firms hold. According to Modigliani and Millers' theory (1958), in a world of perfect capital markets, cash levels are irrelevant to business value, and therefore no relationship is established between liquidity and cash flow.

According to trade-off theory, companies with higher cash flow values, as they expect higher returns at the end of the periods, do not require such high liquidity levels and tend to retain less cash. Hence, Kim et al. (1998) suggest cash flow can be seen as a substitute for liquidity; consequently, cash flows and cash holdings should be negatively related. Regarding cash flow volatility, as companies with greater uncertainty in returns may face periods of negative growth or even loss, they should be prevented with larger amounts of cash holdings, particularly if they are financially constrained companies, due to precautionary reasons (Han and Qiu, 2007). According to this theory, the greater the volatility of firms' cash flows, the greater their liquidity level, as shown by the study by Opler et al. (1999).

The pecking-order theory associates a positive relationship between growth and liquidity, as high-performing companies create larger liquidity reserves at times when investment needs are less than self-financing capacity (Myers, 1984). The free cash flow model does not identify any relationship between liquidity levels and the value of companies' cash flows. The studies by Olper et al. (1999) and Ferreira and Vilela (2004) identified a positive relationship between cash flow and liquidity ratio, which validates the pecking-order theory. The study by Ozkan and Ozkan (2002), when analysing UK companies, found contrary results,

concluding that the sign of the relationship between liquidity stock and cash flow is negative, confirming the expectations of the trade-off theory.

According to studies by Almeida et al. (2004) and Han and Qiu (2007), companies with financial constraints tend to retain more liquid assets due to precautionary reasons. They also concluded that in companies without financial constraints, cash policies are not as sensitive to cash flow values since they find it easier to finance their investments. Han and Qiu's (2007) study extended to cash flow volatility, suggesting that companies without financial constraints do not adjust their cash policy in accordance with the future uncertainty of their cash flows as they may access external financing. The authors arrived at this result because they only found a positive and significant relationship between cash holdings and cash flow volatility in financially constrained companies. It was also suggested that the degree of relationship between these two variables is defined by the level of financial constraints. Contrary to the results found by Almeida et al. (2004) and Han and Qiu (2007), the study by Riddick and Whited (2007) found a negative relationship between liquidity and cash flow, suggesting that companies with higher cash flows do not need to have high liquidity levels because they are able to obtain liquidity through their results. This study also analysed the relationship between cash flow volatility and liquidity, and according to the findings of Han and Qiu (2007), a positive relationship was found.

Boileau and Moyen (2010) while trying to understand the reason for the substantial increase in the average liquidity levels over the years, concluded that the firms' cash holdings are positively influenced by cash flow volatility due to precautionary reasons, meaning that there is a positive relation between uncertainty and cash holdings.

IMF's working paper (2019) addresses corporate cash holdings in innovative sectors, having documented a general tendency in increasing cash holdings in firms located in the most industrialized countries over the last two decades, a trend that is most significant for firms engaged strongly in R&D activities. This study indicates that firms with higher R&D intensity have on average higher cash ratios because (i) firms insure against innovation-induced liquidity risk, i.e., since investment in innovation is subject to liquidity shocks during the R&D phases according to Aghion et al. (2010), firms hold enough cash to insure against such cost, but also because (ii) higher returns associated to innovation often induce firms to hold more cash through accumulated results.

This research also suggests that increasing openness to trade will result in growing returns to innovation: "The demand for liquidity arises from the need to fund cost overruns resulting from long-term investment (such as innovation or other investment in intangible

capital) which in turn are spurred by increased globalization. Rising globalization expands export opportunities for the most productive firms and thus boosts returns to being in the top tail of the distribution." (IMF, 2019, p. 8).

2.3. The Economic Benefits of R&D

2.3.1. The Endogenous Growth Theory

Schumpeter (1942) was the first author to explore the importance of investing in technological innovation with his work on R&D, innovation and entrepreneurship. Until this author's work, the various theories of economic growth did not take into account the innovation variable. With the introduction of the concept of creative destruction by the same author and the conclusion that it is innovation that determines long-term economic cycles, there has been a growing literature on the importance of knowledge for the economy which have led to the consequent and recurring R&D studies. Solow (1957) and Denison (1962) also concluded that economic growth is not explained solely by labour and capital, anticipating the relevance of technological progress in economic growth. It was from Solow's work that the production function came to be used in Schumpeter's Capitalism, Socialism and Democracy.

The author used a Cobb-Douglas function, applying it to economic activity as a whole, and created a production function that made it possible to continually substitute between factors, thus resulting in the marginal product variability of each factor. Although Solow's work and other earlier neo-classical models[4] identify technological change as an essential factor for economic growth, these are criticized for failing to explain one of the main determinants of economic growth, technological progress, since it is considered exogenous.

It was Romer (1986) and Lucas (1988) who started the often referred "endogenous growth theory", by developing models which consider technological change as endogenous in the production function, which suggests endogenously determined technological change generates sustainable economic growth. In Romer (1990), the technological change process must be carried out like any change in the production process that allows an improvement resulting in the creation of new products.

The importance of R&D and technology advances for economic growth has been continuously confirmed and is widely accepted as a critical driver for such. Guloglu and Tekin (2012) are among several authors who find strong evidence that both R&D intensity and the rate of innovation have a positive impact on, and cause, economic growth. Their model results

[4] Ramsey (1928) and Swan (1956).

strongly suggest that endogenous technological change, caused by investment in the R&D sector, is able to promote economic growth. Guloglu and Tekin find that R&D based endogenous growth models are particularly relevant in explaining economic growth in high-income countries, or in other words, the more R&D intensive the economies are, the higher performance they tend to have in the long run, suggesting that both the "technology-push"[5] and "demand-pull"[6] effects are equally present, and both models are equally important for explaining the source of technological change.

This study also suggests that R&D investment increases with the market size and the rate of innovation and that as long as the economy keeps growing and the rate of innovation increasing, firms accelerate R&D intensity. Thus, finding that both R&D and innovation are pro-cyclical, as previously suggested by Schmookler (1966).

2.3.2. Endogenous Growth and Economic Policy

The main difference between the neoclassical theory and the endogenous growth theory is that the latter defends that the rate of progress in technology depends on economic forces, and can be influenced by economic policy. Particularly in the newer versions of the endogenous growth theory, policies supportive of R&D and technology transfer through importation and licencing of foreign technologies are much emphasised.

Barro and Sala-i-Martin (1992) and Evans (1996) mention that in the second half of the 20th century, the long-run growth rate of GDP per capita converged between most countries, which was not taken into account in the first generation of the theory, suggesting that each country's long-run growth rate depends solely on the institutions and policies affecting the incentive to generate and spread innovations.

With these observations of convergence in the long-run growth rates, the endogenous growth theory has been subjected to modifications in order to accommodate the critical force that is the technology transfer from one country to another. Howitt (2000), for instance, points out that "technology transfer fits naturally into the Schumpeterian framework because it works just like the cross-industry technology spill over that was already incorporated in closed-economy versions of the theory" (Howitt, 2004, p.4), meaning that it has the same effect as R&D in a closed economy with its spill over effects through different industries.

[5] Technology-push effect: development of new products resulting from R&D.
[6] Demand-pull effect: effects on innovative activities driven by trends in demand, the competitive structure of markets, and factors affecting the utility of new products or the ability of firms to realize economic benefits.

In either case, the R&D carried out in a particular industry in a particular country will incorporate knowledge obtained from research and innovations taken place elsewhere, either in other industries or countries. Coe and Helpman (1995) and Eaton and Kortum (1996) indicate this adjustment is supported by strong evidence in the effect that R&D expenditure has in Total Factor Productivity (TFP) growth not only within each country but also in their trading partners.

When technology transfer is added to the theory, it predicts all countries performing R&D will have their economies growing at the same rate in the long run, which is coherent with the observations of convergence pointed out by Barro and Sala-i-Martin (1992) and Evans (1996).

"In these modified endogenous growth models, the incentives to perform R&D in a small open country will determine not its long-run growth rate but its long-run TFP level relative to the rest of the world" (Howitt, 2004, p. 5), meaning that increasing R&D will temporarily boost technological progress, and hence TFP growth until getting closer to the world technology frontier. When this happens, it loses "advantage of backwardness", lowering its growth rate again. Even though these country's long-run growth rate will not change, the temporary boost will have permanent effect on the TFP gap separating it from the frontier.

Howitt (2005) also refers that the new endogenous growth models predicts that countries in the bottom R&D expenditure and with no incentives for companies to perform R&D also will not invest in technological change and will not benefit from technological transfer, thus not converging in growth rates but instead grow slower than the technological leaders even in the long-run.

Education also plays an important role in R&D and technology transfer. Griffith, Redding and Reenen (2004) found that education is an important element determining the rate at which an industry in an OECD country can catchup to the world leader in technology in a specific industry. In the theoretical model of Howitt and Mayer-Foulkes (2002), it is shown that the countries educational levels may be important enough to determine the difference between convergence and divergence in growth rates of GDP. This happens because R&D processes require intensive skilled labour but also because education has direct influence on the speed of technological transfer. The greater the level of education of a country, the better its capacity to engage in R&D, technology transfer and ability to adapt to new technologies and work productively with them.

Openness to international trade can also have direct influence in its productivity in the long run by enabling technology transfer. As Keller (2002) highlights, this happens not only by embodying ideas generated elsewhere but also by importing high-tech capital goods.

Focusing on the USA and the United Kingdom, Kocherlakota and Yi (1997) find that there is a combination of exogenous determinants that have significant impact on long-run growth of technological change, namely tax rates and public capital, the first being negatively related and the latter positively related. The authors point out that variations in one have been followed by offsets by the other, which makes sense, as the governments often finance expenditures with increase in taxes, meaning that the effect obtained from most public capital is nullified by increases in taxes. Arora (2001) also suggests government fiscal policy have important implications in the long-run speed of technological progress and TFP, referring to the benefits of long-term deficit reduction which allows reducing expenditure on debt service, thus also allowing reducing taxes without cutting back other services.

Besides the most obvious measures that may influence the rate of technological progress, Howitt (2005) states that more than half of the costs related to industrial R&D within the USA are related to physical capital, such as equipment, laboratories, prototypes, buildings, etc., thus being at least equally important to create conditions for firms to be able to have access to these assets.

Regarding competition, Blundell, Griffith and Reenen (1995) and Nickell (1996) suggest a positive correlation between market competition and TFP growth and innovation within a firm or industry. Coincidently, Porter (1990) also presents evidence supportive of this view, with competition being crucial for firms to innovate in order to survive, an "innovate or die" scenario. Aghion, Dewatripont and Rey (1999) also see competition as a way of reducing agency costs since it reduces the firm's profitability and acts as stimulus for innovation to avoid bankruptcy, at the same time reducing chances of managerial misbehaving and conflict of interest.

Finally, regarding economic policy, Howitt (2005) defends that intellectual property be protected in order to promote technological progress, since weak copyright laws act as incentive for firms and people in general not to innovate. Howitt also refers the USA as example, by mentioning this is the rationale behind the stronger protection of intellectual property.

3. Methodology

The fundamental issue to be addressed in this research is: *What determines the Capital Structure and Liquidity of R&D intensive companies within the EU?* - This implies understanding what is behind the firms' financial decisions, regarding (i) capital structure, analysing what determines the use of debt in order to finance their activity, and (ii) cash and cash equivalents, understanding what determines these companies' financial liquidity.

The identification of such determinants will lead to the understanding of a broader scenario in the financing of R&D intensive companies, by interpreting results and contributing to identifying possible constraints these companies face when financing their activity.

Thus, the answer to this issue will allow subsequent sub-topics to be addressed such as: *Are different types of Capital Structures related to problems in finding investors, or is it simply a matter of strategic financial options? Do R&D intensive companies have different needs of liquid assets? What barriers may be restraining these companies' ability to invest and expand? Where can economic policy intervene in order to provide better conditions for innovative companies to thrive?*

Consequently, the first stage in this research will consist mainly in a quantitative methodology, by gathering relevant data and finding the explanatory variables to the first question using regression models; the second stage will consist in a qualitative analysis, by relating the empirical evidence obtained with topics and conclusions from the literature focused in the main theories of capital structure, cash holdings and economic growth.

Ultimately, it is expected that this research may contribute to understanding the problems R&D intensive firms face when financing their activity and what are the favourable conditions to promote their sustainability, thus also contributing to the literature and hopefully to better institutional and policy framework in the EU.

3.1. Research Hypotheses

The starting point for the upcoming chapter consists in the definition of research hypotheses, which, far from being an evident proposition in itself, may or may not be confirmed - and that, within a scientific elaboration, must necessarily be subject to verification and demonstration procedures. It constitutes a critical link in the investigation process and triggers a demonstration process from its enunciation.

The hypotheses are divided and grouped according to the specific subject of research to which they will serve: Hypotheses A will be tested as determinants of capital structure and Hypotheses B as possible determinants of firms' liquidity. These research hypotheses are based on the main theories on capital structure and liquidity of the firms, reviewed in the previous chapters on the existing literature: *2.1. Main Theories of Capital Structure* and *2.2. Theories Focusing on Corporate Cash Holdings*; additional hypotheses will be presented according to characteristics of the countries where firms are located.

- **Hypothesis A1 (HA1)**: High R&D intensity companies resort less to leverage.

In line with Bartolini (2011) and referring to corporate investments in R&D and innovation, Hall et al. (2015) also suggest that these firms and their activities have characteristics that makes harder to finance relatively to other investments, since they are riskier and often impossible to collateralize. Additionally, such corporate investments raise more problems of opportunistic behaviour, adverse selection and moral hazard caused by information asymmetry between firms and potential investors. Consequently, it is expected that R&D intensive firms, irrespective of their other characteristics, should rely more on issued shares and their internally generated funds.

- **Hypothesis A2 (HA2)**: Dimension is positively related to leverage.

The views on the relationship between firm size and debt are pretty common on the theoretical basis, namely on the three main theories of capital structure, since larger firms tend to have a greater diversification of their activities. This greater diversification of activities means that companies are less exposed to bankruptcy costs and its probability of bankruptcy is reduced. Thus, larger companies tend to increase their debt levels as a result of the lower prospect of bankruptcy and also as a way of obtaining higher tax benefits from the tax deduction of interest.

- **Hypothesis A2.1 (HA2.1)**: The positive effect of dimension on leverage is more expressive in High R&D intensity companies.

Since the dimension of a firm can be considered a proxy for the probability of default, meaning the agency costs should be higher for less established firms, and since this is the main financial restriction for High R&D intensity firms due the high-risk nature of their investments, it is expected that dimension plays a more important role for lenders when rating those companies.

- **Hypothesis A3 (HA3)**: Age is negatively related to leverage.

As confirmed by Michaelas et al. (1999) and Petersen and Rajan (1994) and in line with the pecking order theory, it is expected a negative relationship between firm age and debt, since time should allow firms to accumulate substantial internally generated funds over the time, having no reason to seek external funding.

Frank and Goyal (2003) also had strong evidence that financing deficit declines over time regardless of firms' size.

- **Hypothesis A4 (HA4)**: Growth opportunities are positively related to leverage.

In line with the pecking order theory, it is expected a positive relationship between growth opportunities and debt. According to this theory, firms prefer internally generated funds to finance their investments, but they might not be sufficient to finance them, particularly in cases where firms have high growth rates.

A positive relationship between growth and debt was obtained by several authors such as Toy et al. (1974), Jorge and Armada (2001) and Brito et al. (2007).

- **Hypothesis A5 (HA5)**: Profitability is negatively related to leverage.

This relationship is expected in line with Myers and Majluf (1984) and the pecking-order theory, suggesting firms have clear preference for self-financing over external financing and will only resort to debt if the internally generated funds are insufficient, i.e. the higher the firm's profitability and the internally generated funds the less the use of debt.

Empirical studies such as Toy et al. (1974), Kester (1986), Titman and Wessels (1988), Rajan and Zingales (1995), Fama and French (1998), Cassar and Holmes (2003), Hall et al.

(2004), Graham (2004) and Oliveira (2012) have widely confirmed this hypothesis. Bartolini (2011) finds out that this relationship is more expressive in innovative companies, or in companies with higher R&D expenses, meaning that more innovative firms tend to rely more on internally generated funds, possibly due to higher uncertainty associated with the outcome of future investments on innovation through R&D and higher cost of external financing.

- **Hypothesis A5.1 (HA5.1)**: The negative effect of profitability on leverage is more expressive in High R&D intensity companies.

This hypothesis serves to test the previous statement, that since innovative companies and companies with higher R&D expenses tend to rely more on internally generated funds due to higher uncertainty nature of their activity and higher cost of external financing, profitability should lead these companies to resort more to internally generated funds compared to those whose activity is less risky, in this particular case, referring to Low R&D firms.

- **Hypothesis A6 (HA6)**: Tangibility is positively related to leverage.

As suggested by Myers (1977) and in contribution to the trade-off theory, it is expected that firms with a greater proportion of tangible assets have more ease in higher debt levels since this type of asset suits better as a guarantee for lenders in the case of liquidation. Studies of Titman and Wessels (1988), Rajan and Zingales (1995), Booth et al. (2001) and Oliveira (2012) present empirical evidence of this positive relation.

- **Hypothesis A6.1 (HA6.1)**: The positive effect of tangibility on leverage is more expressive in High R&D intensity companies.

Specifically, regarding High R&D intensity firms, it is expected a more expressive (positive) effect relatively to those having less or no R&D activities since this is associated with risk, meaning companies whose activity depends on R&D are more exposed to risk and asymmetry of information, which should lead lenders to require more collateralization, particularly through tangible assets whose market value should be easier to obtain and should be more stable overtime.

- **Hypothesis A7 (HA7)**: Intangibility is negatively related to leverage.

In opposition to the referred effect of tangibility of assets, in which it is expected that firms with a greater proportion of tangible assets have more ease in higher debt levels, it is expected that more intangible assets will lead companies to lower debt levels for the same (but opposite) reasons Myers (1977) identifies in contribution to the trade-off theory. As Myers (1977) states, while firms with greater proportion of tangible assets can access more external financing, firms with higher proportion of intangible assets will have more difficulty accessing debt, since this type of asset is less liquid and serves less as collateral.

Several authors have confirmed this opposite relationship between intangibles and debt, such as MacKie-Mason (1990), Jensen et al. (1992) and Sibilkov (2009).

- **Hypothesis A8 (HA8)**: Regulatory responses to the 2008-2012 global financial crisis led to a debt reduction in the post-crisis years.

Since the last global financial crisis (2008-2011/2012), as in previous ones, significant changes took place in the banking sector, a consequence of the revealing of substantial weaknesses in the banking system and its framework, which resulted in excessive lending often risky and unsupported by adequate collaterals and liquidity buffers. Since then, regulators have responded by reforming prudential frameworks and by enhancing supervision. In global terms and particularly in corporate credit, measures were similar among regulators (central banks and the Basel Committee), consisting in increased use of stress testing by both banks and supervisors for greater resilience on a forward-looking basis[7].

Following this logic, an obvious consequence is expected: as banks and supervisors tighten conditions in a prudential response to financial crisis, less credit is conceded. This relation should be verified with lag, meaning that in 2010 the EU, as most of the developed countries, was facing a major financial crisis, but most of the bank structural changes should be felt in long-term in respect to corporate credit, thus 2018 will be considered as the year that reflects such changes.

[7] For details on such measures, please read: Committee on the Global Financial System (2018); European Parliament (2018) and European Central Bank (2019).

- **Hypothesis A9 (HA9)**: Country's development is negatively related to leverage.

As suggested by Bokpin (2009), GDP per capita, the proxy used for country's development, may be representative of growth opportunities for firms, allowing them to retain internally generated funds and resort less to external financing. Thus, in line with Bokpin (2009) and the pecking order theory regarding growth opportunities in general, it is expected a negative relation between the development of the countries and debt, since firms will have the opportunity to resort more to internally generated funds when the population holds more wealth and has higher purchase power.

- **Hypothesis A10 (HA10)**: Equity market access is negatively related to leverage.

As suggested in the pecking order theory, firms only resort to issuing new shares as last resort, but this decision should be influenced by the economic environment, particularly depending if economies are more equity- or bank-oriented.

In line with Rajan and Zingales (1995), who found that differences between bank-oriented and equity-oriented countries are reflected in the choice of financing, it is expected ease in equity market access to be negatively related to debt, as firms will have more access to such financing.

- **Hypothesis A10.1 (HA10.1)**: The negative effect of equity market access on leverage is more expressive in High R&D intensity companies.

Again, due to the risky nature of highly innovative firms which can be seen as a financing restraint, it is expected that equity market access will have greater effect on the type of capital structure choices of High R&D intensity companies compared to the remaining. Tech start-ups and innovative firms in general should resort more to this type of financing, being a more suitable economic environment when the market is more equity market-oriented.

- **Hypothesis B1 (HB1)**: High R&D intensity companies hold more cash comparing to Low R&D intensity companies.

IMF's working paper (2019), having documented a general trend in increasing cash holdings in firms located in the most industrialized countries over the last two decades, highlights that

this is particularly significant in firms which are strongly engaged in R&D activities. It is suggested by IMF (2019) that firms with higher R&D intensity have on average higher cash ratios since (i) firms insure against innovation-induced liquidity risk, i.e., since investment in innovation is subject to liquidity shocks during the R&D phases according to Aghion et al. (2010), firms hold enough cash to insure against such cost, but also because (ii) higher returns associated to innovation often induce firms to hold more cash through accumulated results. This can be seen as a financial constraint due to the nature of the investments (high-risk), resulting in low credit ratings and firms retaining more liquidity due to precautionary reasons, a topic widely discussed in the theoretical field, e.g. Ozkan and Ozkan (2002), Almeida et al. (2004) and Han and Qiu (2007).

- **Hypothesis B2 (HB2)**: Dimension is negatively related to liquidity.

Since larger companies tend to have a greater diversification of their activities, this implies that they will be less exposed to bankruptcy costs and, consequently, its probability of bankruptcy is reduced, thus being less likely to accumulate cash reserves (Al-Najjar and Belghitar 2011). Lang et al. (1995) also suggest that large companies can quickly raise cash by selling non-core assets in periods of financial distress, allowing them to have low liquidity most of the time.

- **Hypothesis B3 (HB3)**: Age is positively related to liquidity.

Also, in line with the pecking order theory, it is expected a positive relationship between firms age and liquidity as time should allow firms to accumulate substantial internally generated funds over time. Additionally, older firms have a more extended history of capital market transactions as well as successful operations which should contribute to a better reputation and a lesser degree of information asymmetry, thus being able to obtain better an optimal cash position and continued investments (e.g., Faulkender 2002).

- **Hypothesis B4 (HB4)**: Growth opportunities are positively related to liquidity.

The pecking-order theory associates a positive relationship between growth and liquidity, as high-performing companies create larger liquidity reserves at times when investment needs are less than self-financing capacity (Myers, 1984). Kim et al. (1998) also suggest future investment

opportunities will result in firms investing more in liquidity to have more cost-effective investments due to higher costs of external financing.

- **Hypothesis B5 (HB5)**: Profitability is positively related to liquidity.

Also, in line with the pecking order theory, it is expected that profitability contributes to firms' liquidity since it allows them to accumulate cash reserves to face future economic adversity. IMF (2019) also suggests that companies should be provided with greater cash holdings for precautionary reasons, implying that during favourable economic and financial circumstances, such as high profitability, firms will accumulate cash reserves to face periods of greater uncertainty.

- **Hypothesis B5.1 (HB5.1)**: Profitability's positive effect on liquidity is more expressive in High R&D intensity companies.

In line with Han and Qiu (2007) on financially constrained companies, it is expected that High R&D companies will have a greater precautionary behaviour compared to Low R&D companies, assuming R&D intensity is a proxy for financial constraint due to the inherent risk of its activity.

- **Hypothesis B6 (HB6)**: Leverage is negatively related to liquidity.

The pecking order theory prioritizes internally generated funds over external financing due to its costs, which includes transaction costs, agency costs and bankruptcy costs. In line with this theory, it is expected that debt contributes negatively to companies' liquidity mostly due to its transaction costs, namely interest and associated expenses such as commissions and administrative costs.

Additionally, high-leverage firms are more subject to monitoring, which implies limited managerial power of decision and thus results in lower cash holdings (Drobetz and Grüninger, 2007). Ferreira and Vilela (2004) also show that highly leveraged firms are less able to accumulate cash due to the higher monitoring from the financial institutions.

- **Hypothesis B7 (HB7)**: Shareholder protection[8] is negatively related to liquidity.

Due to the impact of agency problems on corporate cash policies, this relationship is expected in line with Dittmar et al. (2003), who found strong evidence that companies in countries where there is little shareholder protection have higher cash levels than countries with more effective protection mechanisms. This was also supported by studies by Harford (1999), Faulkender and Wang (2006), Pinkowitz et al. (2006) Dittmar and Mahrt-Smith (2007), Harford et al. (2008) and Nikolov and Whited (2009).

[8] Shareholder protection consists in the national legal framework aiming to strengthening of shareholder rights against frauds and agency problems.

3.2. Defining and Identifying R&D Intensive Firms

To address this, a search was made regarding classification of economic activities, and it was concluded that the most commonly used when analysing activities based on R&D is OECD (2016) taxonomy of economic activities based on R&D intensity as follows.

	Manufacturing	R&D as % of GVA	Non-manufacturing	R&D as % of GVA
High R&D intensity industries	303: Air and spacecraft and related machinery	31.69	72: Scientific research and development	30.39
	21: Pharmaceuticals	27.98	582: Software publishing	28.94
	26: Computer, electronic and optical products	24.05		
Medium-high R&D intensity industries	252: Weapons and ammunition	18.87	62-63: IT and other information services	5.92
	29: Motor vehicles, trailers and semi-trailers	15.36		
	325: Medical and dental instruments	9.29		
	28: Machinery and equipment n.e.c.	7.89		
	20: Chemicals and chemical products	6.52		
	27: Electrical equipment	6.22		
	30X: Railroad, military vehicles and transport n.e.c. (ISIC 302, 304 and 309)	5.72		
Medium R&D intensity industries	22: Rubber and plastic products	3.58		
	301: Building of ships and boats	2.99		
	32X: Other manufacturing except medical and dental instruments (ISIC 32 less 325)	2.85		
	23: Other non-metallic mineral products	2.24		
	24: Basic metals	2.07		
	33: Repair and installation of machinery and equipment	1.93		
Medium-low R&D intensity industries	13: Textiles	1.73	69-75X: Professional, scientific and technical activities except scientific R&D (ISIC 69 to 75 less 72)	1.76
	15: Leather and related products	1.65	61: Telecommunications	1.45
	17: Paper and paper products	1.58	05-09: Mining and quarrying	0.80
	10-12: Food products, beverages and tobacco	1.44	581: Publishing of books and periodicals	0.57
	14: Wearing apparel	1.40		
	25X Fabricated metal products except weapons and ammunition (ISIC 25 less 252)	1.19		
	19: Coke and refined petroleum products	1.17		
	31: Furniture	1.17		
	16: Wood and products of wood and cork	0.70		
	18: Printing and reproduction of recorded media	0.67		
Low R&D intensity industries			64-66: Financial and insurance activities	0.38
			35-39: Electricity, gas and water supply, waste management and remediation	0.35
			59-60: Audiovisual and broadcasting activities	0.32
			45-47: Wholesale and retail trade	0.28
			01-03: Agriculture, forestry and fishing	0.27
			41-43: Construction	0.21
			77-82: Administrative and support service activities	0.18
			90-99: Arts, entertainment, repair of household goods And other services	0.11
			49-53: Transportation and storage	0.08
			55-56: Accommodation and food service activities	0.02
			68: Real estate activities	0.01

Figure 1 - OECDs' Taxonomy of Economic Activities

This classification is generally used across OECD countries as it allows a suitable way to summarise and present a number of industrial statistics. It delivers an organisation of industries according to their level of R&D intensity, which consists in a ratio of R&D to value-added within an industry, clustered into five groups (High, Medium-High, Medium, Medium-

Low, and Low R&D intensity industries), following the International Standard Industrial Classification (ISIC Rev. 4).

R&D intensity is typically defined as the ratio of R&D expenditure to an output measure, usually gross value added (GVA) (OECD, 2016). This indicator is typically used at the level of an economy or business sector to measure its relative R&D effort.

This ratio is obtained using the following formula:

$$\left(\frac{R\&D}{GVA}\right)_i = \frac{\sum_c R\&D_{ci}}{\sum_c GVA_{ci}} = \sum_c \frac{R\&D_{ci}}{GVA_{ci}} \frac{GVA_{ci}}{\sum_c GVA_{ci}} \quad (1)$$

$R\&D_{ci}$ and GVA_{ci} are respectively the R&D and the value-added of industry *i* in country *c*. The classification is based on aggregated R&D intensities and value-added of the 29 economies of the sample considered by OECD (2016), using purchasing power parities.

As highlighted in Figure 1 - OECDs' Taxonomy of Economic Activities, the analysis will be focusing mainly on High R&D intensity industries, which includes the following ISICs:

- 303: Air and spacecraft and related machinery;
- 21: Pharmaceuticals;
- 26: Computer, electronic and optical products;
- 72: Scientific research and development;
- 582: Software publishing.

For comparison purposes, particularly on the effect of R&D on capital structure and firms' liquidity, Low R&D intensity industries are also considered, consisting in the following ISICs:

- 64-66: Financial and insurance activities;
- 35-39: Electricity, gas and water supply, waste management and remediation;
- 59-60: Audio-visual and broadcasting activities;
- 45-47: Wholesale and retail trade;
- 01-03: Agriculture, forestry and fishing;
- 41-43: Construction;
- 77-82: Administrative and support service activities;
- 90-99: Arts, entertainment, repair of household goods and other services;
- 49-53: Transportation and storage;
- 55-56: Accommodation and food service activities;
- 68: Real estate activities.

3.3. Sample and Variables

The data set required including relevant data for finding the determinants of firms' financial decisions, thus had to include (i) firm's financial information, (ii) firms' characteristics (dimension, industry and its R&D intensity, age), and (iii) additional macroeconomic data, relevant to test the research hypotheses.

In order to gather such data, a database of financial and business information on Europe's public and private companies was used: Amadeus, developed by Bureau van Dijk / Moody's Analytics. Amadeus provides wide-ranging information for approximately 21 million companies for a total of 34 countries (all EU countries are covered)[9], including several standardised annual accounts (consolidated and unconsolidated), financial ratios, sectoral activities and ownership data. Amadeus data comes entirely from regulatory filings of local governments[10].

From Amadeus BvD, it was possible to extract data by region and ISIC: 303, 21, 26, 72, 582, 64-66, 35-39, 59-60, 45-47, 01-03, 41-43, 77-82, 90-99, 49-53, 55-56 and 68. For each company, the analysis will also focus on the first available year in the database and the last fiscal year whose deadline to submit accounting reports for taxes is due by the time this research was started: 2010 and 2018.

After extracting the data from Amadeus BvD, the first data set comprised a total of 243,426 observations; 121,713 from High R&D intensity companies (2010: 43,612; 2018: 78,101) and 121,713 from Low R&D companies (2010: 41,542; 2018: 80,171). Please note that the 121,713 observations from High R&D intensity companies comprises all the available data on these firms on Amadeus BvD database, having opted to extract the same number of observations for Low R&D intensity companies. It was not possible to extract all the available data on Low R&D intensity companies from Amadeus BvD due to the high number of existing observations: 9,059,019. Both extracting such amount of data and handling it would not be possible. The sample containing Low R&D intensity companies was extracted randomly considering amount of revenues and year.

[9] UK will be included since the research focuses on a time range previous to Brexit.
[10] Based on the description available in Amadeus BvD's institutional website: https://www.bvdinfo.com/en-apac/our-products/company-information/international-products/amadeus

After having the main data extracted from Amadeus BvD, additional (macroeconomic) data was added, sourced from UN, OECD, Eurostat, ECB, Financial Freedom Index, World Bank and CEIC Data[11].

The restructuring and cleaning of this data set followed, having deleted observations based on the following criteria: (i) most of the deleted data was due to missing critical information, which implied deleting an observation every time there was a missing value in one of the explanatory variables; (ii) a residual number of observations (c. 500 in 243,426) were deleted due to having negative values, namely long term debt, loans and cash and cash equivalents; (iii) a residual number of observations (c. 100 in 243,426) were deleted due to having Cash & Cash Equivalent ratio above 100 and negative assets, which was considered to be errors; (iv) a residual number of outliers (c. 100 in 243,426) were deleted for having very high leverage ratios, some close to 2,000,000, which would distort results.

The final sample, the one used in the analysis comprises a total of 85,144 observations, 43,060 on High R&D intensity companies and 42,084 on Low R&D intensity companies. Figure 2 shows the details on the sample distribution on year and R&D intensity.

Year	R&D Intensity	Universe[12]	Sample	
2010	High	43,612	18,359	42.1%
2010	Low	3,708,916	18,104	0.5%
2018	High	78,101	24,701	31.6%
2018	Low	5,350,103	23,980	0.4%
2010 & 2018	High	121,713	43,060	35.4%
2010 & 2018	Low	9,059,019	42,084	0.5%
Total		**9,180,732**	**85,144**	**0.9%**

Figure 2 - Sample Detail on Year and R&D Intensity

The geographic distribution of the sample is represented in the Figure 3, with Italy (21,517), France (12,357) and Spain (8,186) representing c. 50% of the total data (85,144).

[11] Sources of macroeconomic data: GDP per capita and annual growth in productivity and Unit Labour Costs (ULC) by main economic activity (ISIC Rev.4) - sourced from OECD, Eurostat and ECB; Shareholder Protection Index – Based on Investor Protection Index officially measured by the World Bank - sourced from Financial Freedom Index (http://www.financialfreedomindex.com/); Total stock market capitalization of listed domestic companies per country – sourced from the World Bank and CEIC Data (https://www.ceicdata.com/en).

[12] Estimate of universe considering Amadeus BvD data, which should include most of the existing companies (if not all) since the data is obtained from regulatory filings of local governments, considering that account reporting is mandatory for all EU countries mostly for tax purposes.

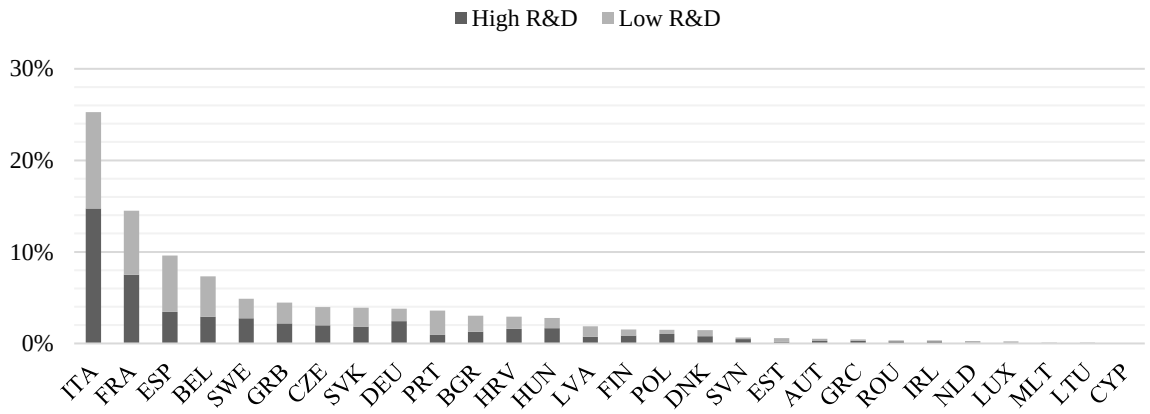


Figure 3 - Geographic Distribution of the Sample

The sample includes data for the variables described in Figure 4.

Variable	**Type of Variable**	**Description**
Leverage	Dependent/Independent	Debt ratio (debt/total assets)
Liquidity	Dependent	Cash & Cash Equivalents ratio (cash & cash equivalents/total assets)
High R&D	Independent	Binary variable for High R&D intensity firms: 1 if the firm integrates an industry classified as High R&D intensive according to OECDs' taxonomy of economic activities; 0 if the firm integrates an industry classified as Low R&D intensive
Dimension	Independent	Logarithm of firms' individual total assets
Age	Independent	Firms' age in years
Growth Opportunities	Independent	Annual growth in productivity and Unit Labour Costs (ULC) by main economic activity (ISIC Rev.4)
Profitability	Independent	Return on Assets after taxes
Tangibility	Independent	Tangible assets ratio (tangible assets/total assets)
Intangibility	Independent	Intangible assets ratio (intangible assets/total assets)
Post-Crisis	Independent	Binary variable for post-crisis period: 1 if the year reflects structural changes in the bank system from the last financial crisis (2018); 0 if the year does not reflect yet structural changes in the bank system from the current financial crisis (2010)
Country's Development	Independent	Logarithm of the country's GDP per capita
Equity Market Access	Independent	Logarithm of the country's stock market capitalization[13]
Shareholder Protection	Independent	Level of protection investors have in a country in relative terms[14], from 0 (if inexistent level of shareholder protection) to 100 (if maximum level of shareholder protection)

Figure 4 - Sample Detail on Year and R&D Intensity

[13] Total stock market capitalization of listed domestic companies per country – sourced from the World Bank and CEIC Data (https://www.ceicdata.com/en).
[14] Based on Investor Protection Index officially measured by the World Bank - sourced from Financial Freedom Index (http://www.financialfreedomindex.com/).

3.4. Estimation Methods

To assess the research hypotheses, regression analysis will be used. Depending on the dependent variables' characteristics, different methods will be employed to estimate the specified econometric models.

For Leverage, whose values are non-negative, Ordinary Least Squares (OLS) is the method that will be used in order to estimate the unknown parameters of the regression model. OLS picks the parameters from a linear function of a set of independent variables by the principle of least squares, aiming to minimize the sum of the squares from the differences between the observed output variable in the dataset and the one projected by the linear function.

In this process, the values of X_1, X_2, …, X_n are input or regression variables and Y the output or dependent variable. The resulting model can be expressed by a simple formula that can be written as:

$$Y = \beta_0 + \beta_1 X_1 + \ ... \ + \beta_n X_n + \varepsilon \qquad (2)$$

where Y may vary between {0, 1,977.09},

β_0 is the expected value of Y when each $X_j = 0$, *j=1, … ,n*

X_l to X_n are the values of k different explanatory variables,

β_0 to β_n are the regression coefficients,

and ε is the residual.

For Liquidity, a fractional logit model will be used to estimate the unknown parameters, the most appropriate way to deal with continuous economic variables bounded between zero and one, according to Papke and Wooldridge (1996), since there is no guarantee that predictions from an OLS regression will lie in the unit interval. This approach avoids this issue by using the logistic regression as a link function:

$$E\ (Y \mid X) = \frac{e^{X\beta}}{1 + e^{X\beta}} \qquad (3)$$

where Y may vary between {0, 1}.

In both models the variables X can be a transformation of the original data and include interaction variables, the later used for testing the research hypotheses that predict a different effect on Leverage or Liquidity of some explanatory variables for High and Low R&D firms.

Besides estimating the unknown parameters, the regression models will also serve as basis to verify input variables' statistical significance using heteroskedasticity-robust standard errors, particularly relevant in large samples, as highlighted by Wooldridge (2008) on OLS and Ramalho and da Silva (2009) on fractional regression models.

4. Empirical Results

4.1. Descriptive Statistics

This section describes the sample in a summarized manner, aiming at the identification of trends or elements that might stand out, starting with the dependant variables: Leverage[15] and Liquidity; then the explanatory ones: High R&D binary, Dimension, Age, Growth Opportunities, Profitability, Tangibility, Intangibility, Post-Crisis binary, Country's Development, Equity Market Access and Shareholder Protection.

4.1.1. Leverage

The information that stands out the most in Figure 5 is the difference between High and Low R&D intensity companies: while the data set presents an average leverage ratio of 15.32 when it comes to High R&D intensity companies, Low R&D ones present an average of 21.58 for the same indicator, a difference of 41% relatively to High R&D intensity companies.

	R&D Intensity	Total	2018	2010
Mean	High & Low R&D	18.41	17.37^{+++}	19.80^{+++}
	High R&D	15.32***	$14.51^{***,+++}$	$16.40^{***,+++}$
	Low R&D	21.58***	$20.32^{***,+++}$	$23.24^{***,+++}$
Minimum	High & Low R&D	0.00	0.00	0.00
	High R&D	0.00	0.00	0.00
	Low R&D	0.00	0.00	0.00
Maximum[16]	High & Low R&D	1,977.09	1,977.09	1,208.84
	High R&D	1,977.09	1,977.09	1,208.84
	Low R&D	1,708.54	1,708.54	1,074.33
Standard Deviation	High & Low R&D	42.37	46.44	36.17
	High R&D	43.21	47.14	37.24
	Low R&D	41.25	45.51	34.73
Observations	High & Low R&D	85,144	48,681	36,463
	High R&D	43,060	24,701	18,359
	Low R&D	42,084	23,980	18,104

***, **, * denote statistically significant differences between High and Low R&D firms at 1, 5 and 10% levels, respectively.

$^{+++}$, $^{++}$, $^{+}$ denote statistically significant differences between 2010 and 2018 at 1, 5 and 10% levels, respectively.

Figure 5 - Descriptive Statistics of the Variable Leverage

It is also noticeable that leverage decreases in both High and Low R&D intensity companies, around -12% from 2010 to 2018.

[15] Leverage is simultaneously a dependent variable and an explanatory variable for Liquidity as described in Figure 4, section 3.3.

[16] Leverage ratios above 100 can be reached when firms have negative equity, resulting in debt higher then total assets.

These differences in means are statistically significant, confirmed by performing t-tests by R&D intensity groups and years as shown in Figure 5, giving a first indication that both HA1: High R&D intensity companies resort less to debt, and HA8: Regulatory responses to the 2008-2012 global financial crisis led to a debt reduction in the post-crisis years, may be true.

This trend shown in the data set is also coherent with publications from Deutsche Bundesbank (2017) and Deutsche Bundesbank (2019), which indicate a residual decreasing indebtedness of non-financial corporations, either through debt ratios or banks' lending rates in the euro area[17].

Figure 6 shows the average leverage ratio by country and R&D intensity, with data differing considerably between countries. Latvia and Ireland are the only countries with an average leverage ratio above 40, while Estonia, UK, Portugal, Slovenia, Spain and Cyprus show an average ratio between 30 and 40; Finland, Belgium, Austria and Netherlands show an average ratio between 20 and 30; the remaining, 16 countries – the majority – have an average leverage ratio below 20. It is also worth pointing out that with very few exceptions (Ireland, UK and Hungary), almost all countries show that, in average, companies from High R&D intensity industries are less leveraged when compared to Low R&D intensity ones.

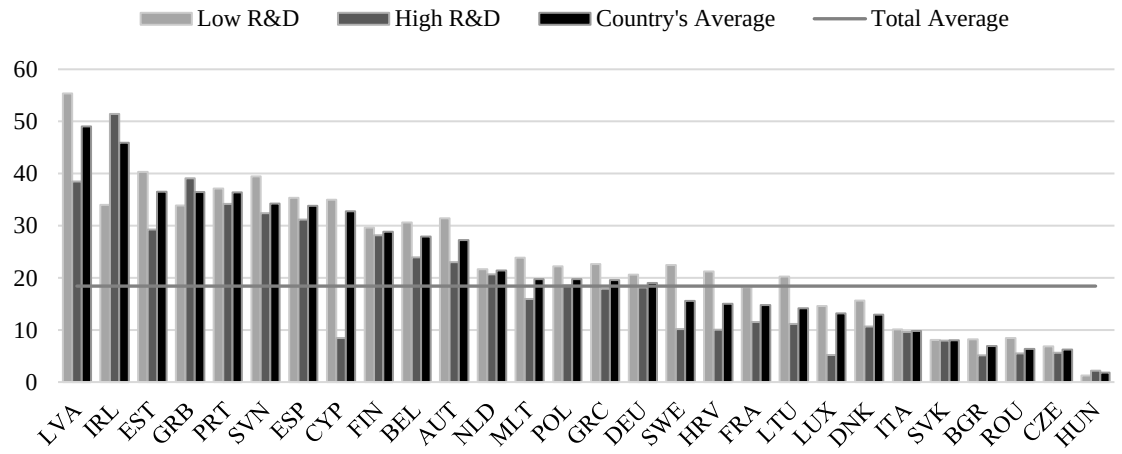


Figure 6 - Leverage Ratio by Country and R&D Intensity

[17] For the sake of the doubt, reference made solely with the purpose of pointing out coherence as the monetary union might not be representative of the entire EU.

Figure 7 shows the percentage of firms according to groups of leverage ratio, with a clear predominance of firms leveraged between 10 and 20 in proportion to total assets.

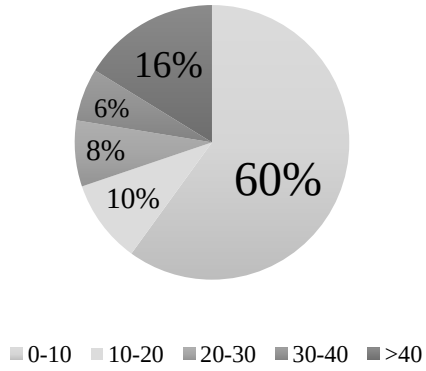


Figure 7 - Leverage Ratio Distribution in Groups

4.1.2. Liquidity

Figure 8 shows that, on average, High R&D intensity companies seem to hold considerably more liquid assets in comparison to Low R&D, around 24% more. It is also evident that there seems to be a general trend for an increase in this indicator, since both High and Low R&D intensity companies had an increase of 8% and 12% respectively, between 2010 and 2018.

	R&D Intensity	Total	2018	2010
Mean	High & Low R&D	19.62	20.40^{+++}	18.58^{+++}
	High R&D	21.70***	$22.41^{***,+++}$	$20.75^{***,+++}$
	Low R&D	17.49***	$18.33^{***,+++}$	$16.38^{***,+++}$
Minimum	High & Low R&D	0.00	0.00	0.00
	High R&D	0.00	0.00	0.00
	Low R&D	0.00	0.00	0.00
Maximum	High & Low R&D	100.00	100.00	100.00
	High R&D	100.00	100.00	100.00
	Low R&D	100.00	100.00	100.00
Standard Deviation	High & Low R&D	24.29	25.13	23.07
	High R&D	24.91	25.69	23.79
	Low R&D	23.44	24.37	22.10
Observations	High & Low R&D	85,144	48,681	36,463
	High R&D	43,060	24,701	18,359
	Low R&D	42,084	23,980	18,104

***, **, * denote statistically significant differences between High and Low R&D firms at 1, 5 and 10% levels, respectively.

+++, ++, + denote statistically significant differences between 2010 and 2018 at 1, 5 and 10% levels, respectively.

Figure 8 - Descriptive Statistics of the Variable Liquidity

These differences in means are also statistically significant, again confirmed by performing t-tests by R&D intensity groups and years as shown in Figure 8, suggesting that HB1: High R&D intensity companies hold more cash comparing to Low R&D intensity companies, may be true.

When analysing the average liquidity ratio by country and R&D intensity, see Figure 9, it is clear that the data differs considerably between countries, Slovakia being the only country with an average close to 40 while Bulgaria and Czech Republic show an average just above 30; Latvia, France, Sweden, Belgium and Croatia show an average ratio between 20 and 30; the majority – 17 countries – have an average liquidity ratio between 10 and 20; Romania, Slovakia and Netherlands just below 10.

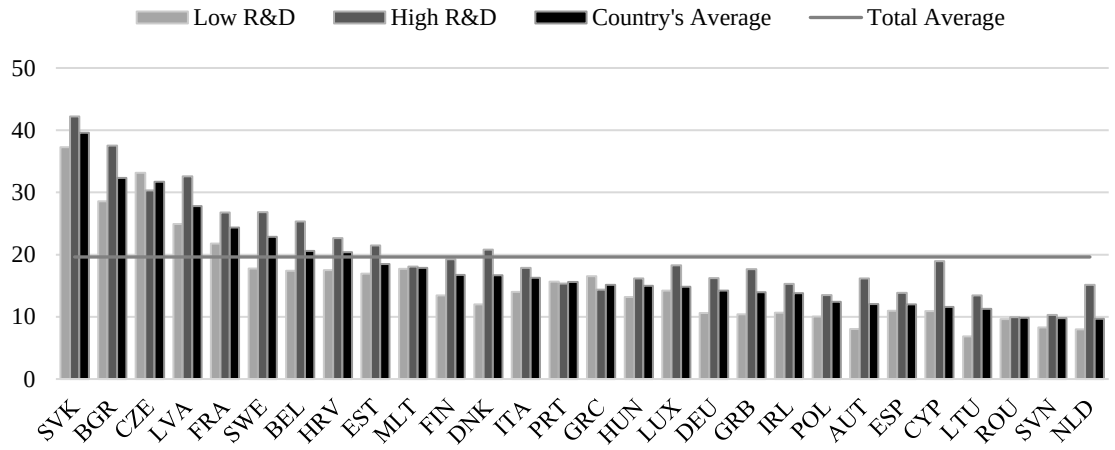


Figure 9 - Liquidity Ratio by Country and R&D Intensity

Figure 10 shows a clear predominance of firms with a liquidity ratio between 10 and 20 in proportion to total assets, representing 52% of the total sample.

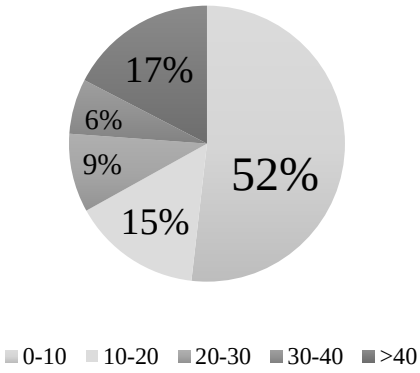


Figure 10 - Liquidity Ratio Distribution in Groups

4.1.3. Explanatory Variables

Figure 11 summarizes the descriptive statistics of the independent variables: High R&D, Dimension, Age, Growth Opportunities, Profitability, Tangibility, Intangibility, Post-Crisis, Country's Development, Equity Market Access and Shareholder Protection. See Figure 4 for a definition of these variables.

Variable[18]	R&D Intensity	Mean	Minimum	Maximum	Standard Dev.	Observations
High R&D	-	-	0.00	1.00	-	43,060
Dimension	High & Low R&D	238,670	0.00	934,476,655	4,739,915	85,144
	High R&D	50,512***	0.00	126,732,000	1,150,464	43,060
	Low R&D	431,191***	0.00	934,476,655	6,635,332	42,084
Age	High & Low R&D	15.25	0.00	212.00	15.59	85,144
	High R&D	15.48***	0.00	200.00	14.86	43,060
	Low R&D	15.00***	0.00	212.00	16.30	42,084
Growth Opportunities	High & Low R&D	3.04	-37.09	29.01	4.88	85,144
	High R&D	4.59***	-21.67	29.01	5.06	43,060
	Low R&D	1.45***	-37.09	21.24	4.12	42,084
Profitability	High & Low R&D	4.41	-100.00	100.00	20.59	85,144
	High R&D	4.87***	-100.00	100.00	22.48	43,060
	Low R&D	3.94***	-100.00	100.00	18.46	42,084
Tangibility	High & Low R&D	22.74	0.00	100.00	27.78	85,144
	High R&D	16.71***	0.00	99.99	21.79	43,060
	Low R&D	28.92***	0.00	100.00	31.63	42,084
Intangibility	High & Low R&D	6.58	0.00	100.00	16.05	85,144
	High R&D	8.82***	0.00	100.00	18.51	43,060
	Low R&D	4.30***	0.00	99.89	12.65	42,084
Post-Crisis	High & Low R&D	-	0.00	1.00	-	85,144
	High R&D	-	0.00	1.00	-	43,060
	Low R&D	-	0.00	1.00	-	42,084
Country's Development	High & Low R&D	27,771	5,124	99,386	10,410	85,144
	High R&D	28,002***	5,124	99,386	10,076	43,060
	Low R&D	27,535***	5,124	99,386	10,736	42,084
Equity Market Access	High & Low R&D	671,103,658	737,734	2,351,775,860	660,681,856	85,144
	High R&D	686,398,096***	737,734	2,351,775,860	663,061,658	43,060
	Low R&D	655,454,515***	737,734	2,351,775,860	657,877,897	42,084
Shareholder Protection	High & Low R&D	54.21	34.00	84.00	9.89	85,144
	High R&D	54.19	34.00	84.00	9.83	43,060
	Low R&D	54.22	34.00	84.00	9.96	42,084

***, **, * denote statistically significant differences at 1, 5 and 10% levels, respectively.

Figure 11 - Descriptive Statistics of the Explanatory Variables

[18] The following variables are in thousands (euros): Dimension, measured in firms' total assets; Equity Market Access, measured in countries' stock market capitalization.
As described in Figure 4, section 3.3., the variables Dimension, Country's Development and Equity Market Access will be converted to logarithm when used in the regression models; for descriptive statistics purposes these are presented in the original format.

Data shows a clear difference in the company's dimension, measured in total assets, suggesting High R&D intensity firms have more difficulty in growing: while the average total assets owned by High R&D intensity companies is c. €51M, total assets owned by Low R&D ones is c. €431M, representing, on average, over 8x the size of High R&D intensity companies.

Both Low and High R&D intensity firms have an average of 15 years since foundation.

When measuring growth opportunities according to years' output and labour costs for their respective sectors, firms within High R&D intensity sectors had clear advantage over Low R&D ones in both 2010 and 2018, with High R&D intensity companies presenting an average growth in productivity and labour costs of 4.59% in comparison to the previous year, versus 1.45% in Low R&D intensity industries.

Coherently, the average profitability, measured in Return on Assets before taxes, also presents itself higher in High R&D intensity companies (4.87% vs 3.94%).

In average, Low R&D intensity companies hold considerably more tangible assets in proportion to total assets, about 73% more, which might be explained by the nature of the industries' activity, in which innovative companies are less tangible capital intensive comparatively to less innovative ones, the latter often being more dependent on buildings and heavy machinery.

The exact opposite can be said about intangibility, since High R&D intensity companies hold considerably more intangible assets in proportion to total assets, about 2x more, which might also be explained by the nature of the industries' activity, with innovative companies holding more intangible assets comparatively to less innovative ones, such as trademarks, patents and copyrights.

The difference in Country's Development average measured in GDP per capita between companies from High and Low R&D intensity industries, €28,002 vs €27,535 respectively, suggests innovative companies are more successful in developed countries.

On Equity Market Access measured in country's stock market capitalization, the statistically significant difference suggests innovative companies depend more on equity, thus thriving better in economies with greater stock markets, which seems to confirm HA1: High R&D intensity companies resort less to debt, subject to further confirmation in inference tests.

Shareholder Protection's difference in average between companies from Low and High R&D intensity companies is not statistically significant, meaning both groups enjoy the same conditions on this indicator.

4.2. Correlation Analysis

Both figures 12 and 13 include only continuous explanatory variables, meaning these do not include binary and interaction variables.

Figure 12, with Pearson Correlation Coefficients which can range from -1 to 1, shows that in general, there is no strong correlation between variables with the exception of Country's Development and Equity Market Access (0.7461).

Variable	Dimension	Age	Growth Opportu-nities	Profitabi-lity	Tangibility	Intangibi-lity	Post-Crisis	Country's Development	Equity Market Access	Leverage	Shareholder Protection
Dimension	1.0000										
Age	0.4505	1.0000									
Growth Opportu-nities	-0.0173	0.0070	1.0000								
Profitability	0.0397	0.0384	0.0367	1.0000							
Tangibility	0.0458	0.0367	-0.0781	-0.0780	1.0000						
Intangibility	0.0572	-0.0897	0.0040	-0.1537	-0.1893	1.0000					
Post-Crisis	-0.0226	0.0276	-0.1099	0.0025	-0.0235	0.0413	1.0000				
Country's Development	0.2786	0.1632	-0.0574	-0.0375	-0.0917	0.1419	0.0797	1.0000			
Equity Market Access	0.3338	0.1785	-0.1405	-0.0350	-0.1036	0.1339	-0.0606	0.7461	1.0000		
Leverage	0.0238	-0.0142	-0.0349	-0.1440	0.1490	0.0317	-0.0284	0.0318	-0.0013	1.0000	
Shareholder Protection	0.1877	0.0878	-0.0456	-0.0043	0.0021	0.0562	0.0114	0.3822	0.2115	0.0876	1.0000

Figure 12 - Pearson Correlation Coefficients

Nonetheless when testing variables' Variance Inflation Factors (VIFs), shown in Figure 13, there is clear confirmation that there is no risk of multicollinearity since no value is close to 10, the threshold from which is usually considered the existence of correlation between predictors.

Variable	**VIF**
Dimension	1.41
Age	1.29
Growth Opportunities	1.06
Profitability	1.06
Tangibility	1.10
Intangibility	1.11
Post-Crisis	1.07
Country's Development	2.70
Equity Market Access	2.58
Leverage	1.05
Shareholder Protection	1.22
Mean VIF	**1.42**

Figure 13 - Variance Inflation Factors

4.3. Multivariate Analysis

4.3.1. Leverage

The two models presented in Figure 14 differ by (1) excluding and (2) including interaction variables. The results show that most of the explanatory variables are statistically significant, with the exception of the interaction variables High R&D*Dimension and High R&D*Profitability. The interaction variables are jointly significant at the 1% level, suggesting model (2) is indeed a better option compared to model (1), thus this will be the model on which the analysis will emphasize.

Model / Variable	OLS	
	(1)	(2)
High R&D	-3.477906*** (0.3013786)	-12.25338*** (4.803075)
Dimension	0.4181504*** (0.069103)	0.3927093*** (0.0735817)
High R&D*Dimension		0.1156913 (0.1258768)
Age	-0.0650683*** (0.0092294)	-0.0648709*** (0.0093572)
Growth Opportunities	-0.1270783*** (0.0282333)	-0.1183709*** (0.0283718)
Profitability	-0.257846*** (0.0153659)	-0.2417983*** (0.0216889)
High R&D*Profitability		-0.0255194 (0.0299572)
Tangibility	0.2070837*** (0.0056352)	0.2182834*** (0.0071248)
High R&D*Tangibility		-0.0328258*** (0.0115013)
Intangibility	0.1026537*** (0.0105562)	0.100013*** (0.0107631)
Post-Crisis	-3.188088*** (0.276793)	-3.205551*** (0.2769761)
Country's Development	7.901596*** (0.5236391)	7.751347*** (0.5230561)
Equity Market Access	-1.472802*** (0.1856118)	-1.68333*** (0.2156122)
High R&D*Equity Market Access		0.4521439** (0.2324813)
F tests for joint significance		
- All variables	346.58***	258.29***
- Interaction variables	---	4.17***
Observations	85,144	85,144

(1) exclude and (2) include the interaction variables, respectively.

***, **, * denote variables and tests statistically significant at 1, 5 and 10% levels, respectively.

Heteroskedasticity-robust standard errors in parentheses.

Figure 14 - Regression Results for Leverage

Concerning the research hypotheses, results fully support HA1, confirming High R&D intensity companies resort less to debt, compared to Low R&D intensity ones, which is coherent to the nature of their activities and investments since these firms have characteristics that makes harder to finance relatively to others, namely being riskier and often impossible to collateralize.

This leads to the results on the explanatory variable Tangibility, supporting HA6, meaning tangibility is positively related to leverage, as firms with a greater proportion of tangible assets have more ease in higher debt levels since this type of asset suits better as a collateral. Consistently, results also indicate dimension is positively related to debt (HA2), as larger firms tend to have a greater diversification of their activities, reducing the risk of bankruptcy and allowing increasing their debt levels as a result, but also tend to have greater sources of collateralization. However, unlike what was postulated in hypothesis HA2.1, the effect of dimension on leverage is similar for High and Low R&D companies, as revealed by the non-significant coefficient of the interaction variable involving the variable Dimension.

Hypothesis HA6.1 is also refuted, since the effect of tangibility on High R&D intensity companies' debt, although positive, is less expressive than in Low R&D companies. This might be explained for a number of reasons such as typically holding few tangible assets, the risky nature of their activities, which may play an important role in stress testing by most banks, and by resorting more to other types of financing.

Regarding the effect of intangible assets on debt, contrary to what was suggested in HA7, these types of assets also seem to serve as collateral as it presents itself as a positive influence on companies' leverage in general, although results show its effect its considerably lower when compared to tangible assets (about half).

Results also support HA3: Age is negatively related to leverage, coherent to what was suggested previously, as time should allow firms to accumulate internally generated funds over the time.

Concerning profitability, results confirm HA5, as it is negatively related to leverage, and corroborate the pecking-order theory, which claims that firms have preference for self-financing over external financing and will only resort to debt if the internally generated funds are insufficient, i.e. the higher the firm's profitability and the internally generated funds the less use of debt. Hypothesis A5.1, suggesting the negative effect of profitability on leverage is more expressive in High R&D intensity companies, is also confirmed. This higher effect of profitability on leverage in High R&D companies is possibly due to the higher uncertainty nature of their activity and the higher cost of external financing, which should lead these

companies to resort more to internally generated funds compared to those whose activity is less risky.

Contradictorily to HA4, results indicate growth opportunities are negatively related to debt. This was predicted by Myers's (1977) and supported by results from Smith and Watts (1992) and Rajan and Zingales (1995), interpreted with the assumption that firms choose shorter debt maturities when anticipating growth opportunities, meaning that periods of greater effective growth opportunities no longer reflect the use of debt in investments, as it may already matured.

Relatively to the financial crisis' influence on leverage, results confirm HA8, since the dummy variable Post-Crisis reflects structural changes in the banking sector as consequence of the revealing of substantial weaknesses, resulting in tighten conditions in conceding credit.

The results diverge from HA9, indicating countries' development is positively related to debt. This is possibly due to the bank sectors thriving better in developed economies or vice-versa, as Demetriades and Hussein (1996) indicate by obtaining bi-directional results on the relation between financial[19] and economic development.

HA10, suggesting equity market access is negatively related to leverage, is confirmed by results, indicating that although firms only resort to issuing new shares as last resort, this decision should be influenced by the economic environment, depending on whether economies are more equity market- or bank-oriented. The more equity market-oriented an economy is, the less its companies will resort on leverage and more on issuing equity.

In contrast, results indicate HA10.1 is not true, as the equity market access effect on High R&D intensity companies' debt is less expressive. This might be explained by innovative companies resorting more to this type of financing as stated by Hall (2010) and confirmed by results from this research, since debt financing is more difficult due to the intangible nature of their investment, information asymmetry and moral-hazard issues. Because these firms are more likely to finance themselves with equity than debt, it is also coherent that more equity financing options will have less impact on their capital structure.

[19] Hussein and Demetriades (1996) use, as proxy for financial development, (i) the ratio of bank deposit liabilities to nominal GDP and (ii) the ratio of bank claims on the private sector to nominal GDP.

4.3.2. Liquidity

The two models presented in Figure 15 differ by (1) excluding and (2) including the interaction variables. The results show that in model (2) all the explanatory variables are statistically significant including the interaction variable, suggesting model (2) is indeed a better option compared to model (1), so this will be the model on which the analysis will emphasize.

Model / Variable	Fractional Logit	
	(1)	(2)
High R&D	0.2700969*** (0.0113288)	0.3073709*** (0.0122471)
Dimension	-0.2131551*** (0.0028232)	-0.2129889*** (0.0028228)
Age	0.0008628** (0.000408)	0.0010208*** (0.000406)
Growth Opportunities	0.0062384*** (0.0010394)	0.0062879*** (0.0010404)
Profitability	0.0105579*** (0.000301)	0.0139455*** (0.000471)
High R&D*Profitability		-0.0055754*** (0.0005951)
Leverage	-0.0078428*** (0.0006426)	-0.0078072*** (0.0006421)
Shareholder Protection	0.0029018*** (0.0005666)	0.0027117*** (0.0005667)
F tests for joint significance		
- All variables	11,400.99***	11,650.45***
Observations	85,144	85,144

(1) exclude and (2) include the interaction variables, respectively.

***, **, * denote variables and tests statistically significant at 1, 5 and 10% levels, respectively.

Robust standard errors in parenthesis.

Figure 15 - Regression Results for Liquidity

Results fully support HB1, confirming High R&D intensity companies hold more cash and cash equivalents comparing to Low R&D intensity companies, as suggested by IMF's working paper (2019), describing a general trend in increasing cash holdings in firms located in the most industrialized countries, highlighting that this is particularly important in firms which are strongly engaged in R&D activities. According to IMF (2019) this is due to (i) these firms insure against innovation-induced liquidity risk, since investment in innovation is subject to liquidity shocks during the R&D phases (Aghion et al., 2010) and (ii) higher returns

associated to innovation often induce firms to hold more cash through accumulated results. This can be seen as a financial constraint due to the (high-risk) nature of the investments, resulting in low credit ratings and firms retaining more liquidity due to precautionary reasons.

Results also support HB2, confirming dimension is negatively related to liquidity. This should be explained by larger companies tendentially having greater diversification of activities, which implies that they will be less exposed to bankruptcy costs and, consequently, its probability of bankruptcy is reduced, thus being less likely to accumulate cash reserves (Al-Najjar and Belghitar 2011). Lang et al. (1995) also suggest that large companies can quickly raise cash by selling non-core assets in periods of financial distress, allowing them to have low liquidity most of the time.

HB3 it is also validated, confirming age is positively related to liquidity. The most plausible explanation for this hypothesis is that time should allow firms to accumulate internally generated funds over time. Additionally, older firms have a more extended history of capital market transactions as well as successful operations which should contribute to a better reputation and a lesser degree of information asymmetry, thus being able to obtain better an optimal cash position and continued investments (e.g., Faulkender 2002).

Relative to HB4, results also indicate that growth opportunities are positively related to liquidity, possibly due to high-performing companies creating larger liquidity reserves at times when investment needs are less than self-financing capacity (Myers, 1984), but also because, as Kim et al. (1998) suggest, future investment opportunities may result in firms investing more in liquidity to have more cost-effective investments due to higher costs of external financing.

The results also confirm profitability is positively related to liquidity (HB5), corroborative that profitability allows them to accumulate cash reserves to face future economic adversity. Contrary to what was expected in HB5.1, results show that profitability's positive effect on liquidity is less expressive in High R&D intensity companies, possibly for having scarcer resources for investment opportunities, thus less cash is retained when profitability increases, investing more in such circumstances.

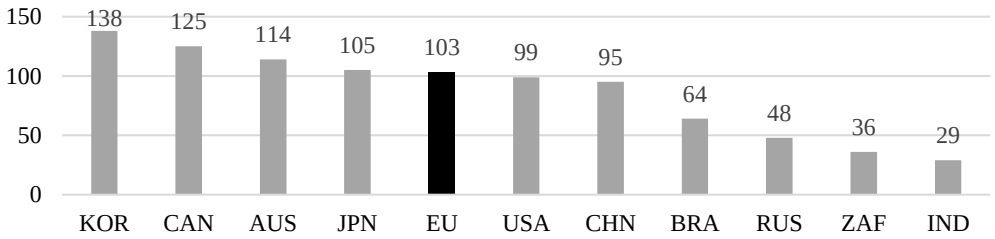
Results also show that leverage is negatively related to liquidity as suggested in HB6, which points out that debt contributes negatively to companies' liquidity mostly due to its transaction costs, namely interest and associated expenses such as commissions and administrative costs. Additionally, high-leverage firms are more subject to monitoring, which implies limited managerial power of decision and thus results in lower cash holdings (Drobetz and Grüninger 2007).

Surprisingly and contrary to a vast literature on the subject[20], results on **s**hareholder protection are divergent to HB7, meaning this is positively related to liquidity. Iskandar-Datta and Jia (2013) obtain the same result, finding that poor investor protection is associated with lower, not higher, cash holdings and documenting at the same time that firms overinvest when holding excessive cash reserves, and this tendency for overinvesting is magnified when investors are not well protected, reducing firms' performance. In other words, agency problems may lead firms to hold less cash reserves to protect themselves from overinvesting and compromise performance, but when country-level governance is strong, such behaviour changes as this same agency problems between managers and shareholders is mitigated.

[20] Mentioned in the literature review and the research hypothesis HB7: Harford (1999), Dittmar et al. (2003), Faulkender and Wang (2006), Pinkowitz et al. (2006), Dittmar and Mahrt-Smith (2007), Harford et al. (2008) and Nikolov and Whited (2009).

5. Economic Policy for R&D Intensive Companies

As previously discussed in section 2.3., there is consensus amongst the academic community that technological change generates sustainable economic growth, which has been continuously confirmed, with several authors suggesting R&D based endogenous growth models are particularly relevant in explaining economic growth, proving the more R&D intensive the economies are, the higher performance they tend to have in the long run. For this reason, it seems unquestionable that for any economy to remain competitive, there is a constant need to invest in R&D, especially the ones that compete for leadership in technology, such as the case of the EU (see Figure 16).



Source: Adapted from European Commission (2020)

Figure 16 – Innovation Index: Leaders in 2019 Relative to EU in 2012[21]

For that to happen, basic conditions must be satisfied, which include innovative firms' ability to invest in projects and finance their operations, allowing efficiency of R&D in terms of economic results. Access to funding as one of the main obstacles for prompting R&D into the commercialisation of innovative products or services is confirmed by European Commission (2014a).

As widely mentioned, High R&D intensity companies have characteristics that makes them harder to finance relatively to others since they are riskier and more uncertain, which holds consequences both for their equity financing – since investors discount this uncertainty on stock markets – and for their debt financing – when collateralisation becomes difficult or even impossible. This becomes clear with the confirmation that High R&D intensity companies resort less to debt, compared to Low R&D intensity ones; the fact that collateralisation is more difficult for these companies, since typically they hold fewer tangible assets and intangible assets do not seem to serve as good for this end; and equity market access playing a major role in the financing of innovative companies.

[21] Innovation index measured using a composite indicator which summarizes the performance of a set of indicators, grouped into four main types - structural conditions, investments, innovation activities and impacts - capturing a total of 27 sub indicators. Base value is the EU in 2012 (=100), meaning values above 100 represent better performance compared to EU in 2012, and values below 100, worst performance compared to EU in 2012.

This allows answering the research topic: *Are different types of Capital Structures related to problems in finding investors, or is it simply a matter of strategic financial options?* – Although firms have preferences in types of financing and the pecking order theory appears to apply in general terms, it also seems clear that High R&D firms' capital structure is mainly defined by tools at their disposal more than by their own financial decisions, as external financing is often possible only when firms present low risk of default or have more available assets to offer as guarantee, with a tendency for aggravation after each financial crisis as banks increase standards in stress testing.

This risk also reflects in these firms' liquidity, as they hold more liquid assets to insure against innovation-induced liquidity risk, behaving as financial constrained companies with low credit ratings and retaining more liquidity due to precautionary reasons, which answers to: *Do R&D intensive companies have different needs of liquid assets?*

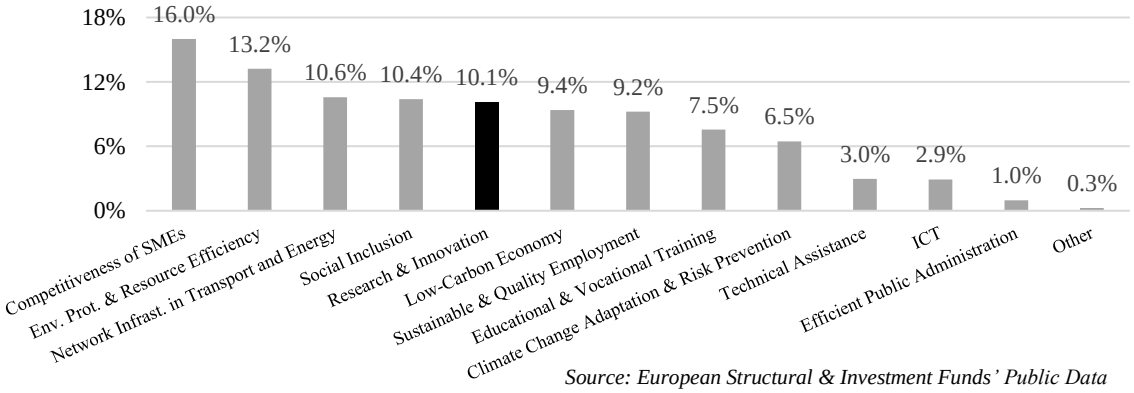
Addressing the topic *what barriers may be restraining these companies' ability to invest and expand?* – Most of the determinants that were analysed are not controllable or exogenous to firms' financial performance, often depending on market conditions and the commercial success of the companies, such as dimension, age, profitability, growth opportunities and cyclical stage of the economy and country's development; so, *where can economic policy intervene in order to provide better conditions for innovative companies to thrive?* – This can be done by providing these firms financing options, specially at earlier stages and during crises, as well as enforcing shareholder protection which seems to be related to firms' performance and ability to reach desired liquidity levels.

In respect to financing options there are three main ways economic policy can intervene: (i) direct funding; (ii) equity financial instruments; and (iii) public entities to serve as personal guarantee.

Concerning (i) direct funding and as described in European Commission (2014b), the EU offers directly and jointly with each member state, a wide range of funds that are channelled through the 5 European structural and investment funds focusing on five areas: R&D and innovation, digital technologies, support for the low carbon economy, sustainable management of natural resources, and SMEs. One of the main goals of one of these funds, the European Regional Development Fund (ERDF), is to increase the expenditure in R&D in proportion to GDP, and particularly for R&D projects funds are usually conceded in the form of grant, meaning that they do not have to be paid back, and are offered in special conditions to SMEs and smaller projects. Although these programs offer good conditions, covering up to 100% of the costs in case of R&D activities, and are great alternatives to other types of financing, only

a small portion of the projects (14%-20%)[22] are approved, leaving behind a great percentage of potentially good projects. In addition, these advantageous conditions only apply to R&D projects, as other types of investments from the same R&D intensive companies such as production or operational equipment, are not so advantageous, as these types of investment are subject to national programs and rules which often opt to use this incentives in the form of loan[23] covering 50, 60, or up to 85% of the investments depending on the economic development of the region (the average co-financing of such expenses is 64% according to European Structural & Investment Funds' Public Data[24]).

Concerning the low approval rate for R&D grants, it reflects the high number of eligible proposals that cannot be financed due to strategic options of the EU, who allocates a small portion (c. 10% or 64.5 billion euros) of its resources to Research and Innovation projects, as shown in Figure 17. Because this is an ideologic matter and involves a much broader analysis of several economic, environmental and social issues, such choice will not be discussed.



Source: European Structural & Investment Funds' Public Data

Figure 17 – EU Financing Budget by Theme 2014-2020

In contrast, it appears incoherent that all productive investments enjoy the same financing conditions regardless of sector. As EU's objective is to strategically invest in research and innovation, it seems clear that for the most innovative companies, who have additional problems in financing themselves, it would be particularly important to benefit from special treatment. This is also justifiable since R&D intensive companies should contribute to higher qualified jobs, higher GVA and greater technological progress of the economies.

[22] According to European Commission report on Horizon 2020: https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/horizon_2020_first_results.pdf.
[23] These loans are usually free of commissions and interests, unless if mixed with banks, in which case loans will have pro-rata conditions.
[24] European Structural & Investment Funds' Public Data extracted here: https://cohesiondata.ec.europa.eu/d/e4v6-qrrq.

The EU has also implemented programs with (ii) equity financial instruments through the European Investment Bank (EIB). One of the EIB's main objectives is to allocate public financial resources in venture capital and private equity funds that support high-growth and innovative small businesses in Europe. According to EIB (2020), during 2019, only 6.7 billion euros were approved through equity operations for innovation projects versus 64.5 from EU grants and loans, which shows how under representative this instrument is. It is particularly relevant to improve this type of financing in the EU since innovative companies clearly lack financing conditions as previously referred, which is also confirmed when comparing US and EU in market capitalization of domestic listed companies in proportion to GDP, which represents 148% versus 68%[25], respectively. The success of the US, EU's main competitor, in having some of the most technological advanced companies achieving the greatest possible dimension may be in good part explained by such highly developed stock market. It is also worth mentioning again that equity financing is more cost advantageous when compared to debt, also suffering from less information asymmetry.

An alternative instrument to support the financing of innovative companies is (iii) public entities to serve as personal guarantee due to their difficulty in offering collaterals for loans, since they typically hold fewer tangible assets and intangible assets do not fit this purpose so well, because banks often have trouble in appraising such assets. The EIB offers this solution indirectly since this type of financial support is made through commercial banks and other financial institutions, subject to request and analysis of a pre-existent or to be created portfolio of credits. The limitations of such initiative from the EIB seems obvious, as the existing portfolios most likely already enjoy some type of guarantees, and even for the to be created portfolios, there seems to be no distinction between companies from different sectors, resulting in banks opting for the lowest risk companies, regardless of having guarantee from the EIB.

All these interventions from the EU are particularly relevant for (i) the least developed countries and regions, which typically enjoy less development financial markets as previously referred; and (ii) younger and smaller firms who have more risk of bankruptcy, less sources of collateralization and less time and dimension to accumulate internally generated funds, which include R&D intensive companies as suggested by the results in section 4.1.

Although not as critical and not equity or debt financing, it is worth mentioning that fiscal benefits from R&D activities can have an important contribute to firm's liquidity, which

[25] Based on data from World Bank and CEIC Data.

can only be done at a national level, since this depends on the individual country's fiscal system and entities, which are independent and heterogeneous.

One of the conclusions from this research is that shareholder protection is positively related to liquidity, which according to Iskandar-Datta and Jia (2013) who obtain the same result, means that overinvestment is magnified when investors are not well protected, reducing firms' performance (less profitability equals less liquidity as seen before) due to agency problems between managers and shareholders. Although EU already has an authority that fights for safeguarding the stability of the EU's financial system and the harmonisation of conduct of business rules - the European Securities and Markets Authority (ESMA) - there is a long way to go, reflected on the Investor Protection Index measured by the World Bank and used in this research, which demonstrates great disparities between countries within the EU, as shown in Figure 18.

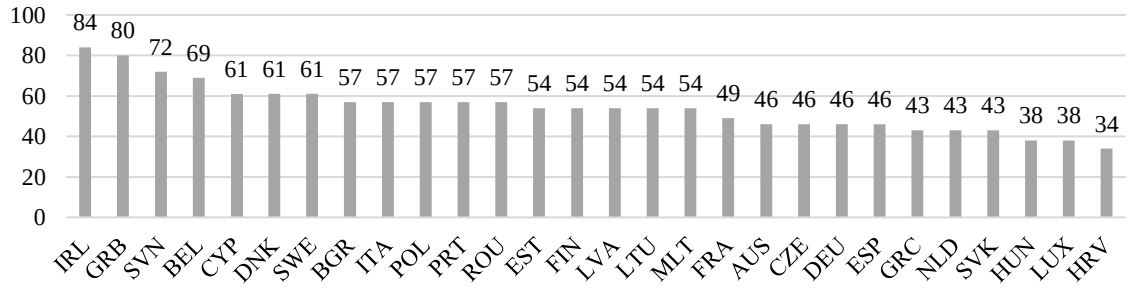


Figure 18 – Investor Protection Index in EU Countries

6. Conclusions

Results show that R&D intensive companies need more financing solutions compared to other companies, both for projects (debt or equity) and operations (liquidity), since they have characteristics that makes them harder to finance relatively to others for being riskier and often impossible to collateralize. Results also show that this kind of financial assistance is particularly important in the first years, while they are less dimensioned, after financial crises, and in less developed countries, which should also have less developed financial systems.

If these companies are financially assisted in these phases, EU's path to achieve objectives in innovation and R&D should have an improvement with more innovative companies overcoming such barriers and surviving at more difficult stages, but also allowing efficiency of R&D in terms of economic results, leading R&D into the commercialisation of innovative products or services.

To this end and as previously suggested, some political initiatives should be revised, namely and above all conditions of EU's grants and loans for non-R&D investments by these companies, more investment (from EU) through equity financial instruments such as venture capital and private equity funds supporting high-growth and innovative small businesses, and EIB reviewing its model to serve as guarantor for these companies (which substitutes collaterals) by offering direct instead of indirect support through financial institutions.

Finally, greater reinforcement of investor protection seems to be necessary, especially in countries with a lower index, for impacting companies' performance and consequently its capacity to achieve higher liquidity ratios.

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