THE IMPACT OF INNOVATION INTENSITY ON THE UNDERPRICING OF INITIAL PUBLIC OFFERINGS

EVIDENCE FROM EURONEXT STOCK EXCHANGE

MASTER THESIS | FINANCIAL MANAGEMENT | BA
ANNABEL BOONMAN | S1731157 | OCT 2021

UNIVERSITY OF TWENTE.

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ENSCHEDE | OCTOBER 2021
PAGES | 81

MASTER THESIS
FINANCIAL MANAGEMENT
BUSINESS ADMINISTRATION
UNIVERSITY OF TWENTE | BMS

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Acknowledgements

With the writing of this master's thesis, I am concluding my master's degree in Financial Management of Business Administration. I would like to thank my first supervisor Dr. Svetlova for the valuable theoretical support I received while doing my research. In addition, I would also like to thank my second supervisor Dr. Ir. Preziuso for sharing his insights to further improve my research.

With the completion of my graduation research, my time as a student also comes to an end. I have not really enjoyed the home stretch, but I have certainly enjoyed my time as a student at the University of Twente. I would like to thank the employees of the university library for the facilitating support of my graduation process. Also, a special thanks to Edwin for sharing his thesis experience, Fabian for his company during pause walks, Thijs for his patience and Mardjolein for accompanying me during long study days and restoring training sessions.

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September 2021

Abstract

Exceptional returns from first day trading Initial Public Offerings (IPOs) are widely described in financial literature. This thesis investigates the effect of the IPO firm's innovation intensity on the underpricing of European IPOs with 115 Euronext IPO observations from 2011 till 2021. The information asymmetry theory is applied as explanation for underpricing and states that more existing information asymmetry increases the underpricing of an IPO. As measurement of innovation, Research & Development (R&D) investment ratio is considered as innovation input variable and the number of patents as innovation output variable. Because of the accounting related differences between GAAP and IFRS that influence information provision, the innovation input variable in this research is split into expensed and capitalized R&D. Based on the information asymmetry theory, it was expected that the expensed R&D ratio would increase underpricing (measured as initial return) and that with a higher capitalized R&D ratio or a higher number of patents the underpricing would decrease. The regression analysis resulted in no significant results of an effect.

This result implies that despite the literature-based expectation there is no influence of innovation on IPO underpricing in this European IPO sample. This seems to be a new result compared to a few important previous studies. An explanation for this can be found in changes in the IPO market in terms of popularity, characteristics of IPO companies and the way IPOs are organized. Also modern investment goals on sustainability can play a role in the innovation within a company.

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1. Introduction

1.1 Background information

Recently Cloud infrastructure company Snowflake entered the market as the largest software Initial Public Offer (IPO) ever with a market value of $33.3 billion. For some investors, this deal was the evidence that the history of the Dot-com bubble from 1995 to 2000 is repeating itself.

> The Dot-com bubble was a rapid rise in the value of technology stocks in the US caused by speculation of Internet related companies (by investors). The number of IPOs in both US and Europe was high during that period (appendix A (Ritter, 2020)). The underpricing of the IPO reached astronomical levels during this bubble and in 1999 the first-day return was as high as 73 precent according to Ljungqvist & Wilhelm jr. (2003) and 65% over the Years 1999 and 2000 according to Ritter & Welch (2002).

Nevertheless, according to Maffiulli (2020), this first day return of Snowflake is an exceptional level and there is currently no evidence of overvaluation of the stock market. Stock valuations today are much lower compared to 1999 and more in line with investor expectations than at the end of the last century during the Dot-com bubble (see appendix B) and that is an important difference.

Many past studies show that on average high returns can be achieved on IPO shares where underpricing is a major factor. In the 1980s, the average first day return on an IPO was 7% and between 1990-1998 it even doubled to an average of 15% (Loughran & Ritter, 2004). Loughran & Ritter (2004) found in their study that between 2001 and 2003 there was a first day return of 12% on average in the US. Ritter and Welch (2002) found an undervaluation of 18.8% in the US from 1980 to 2001. This level is partly explained by the level of underpricing during the Dot.com bubble with which this introduction started. Ibbotson, Sindelar & Ritter (1994) stated that the average first day return is about 10-15%. However, the first day return varies across environment and time (Loughran & Ritter, 2004). A total average is therefore difficult to determine and relatively unreliable and unusable. In the case of the innovative company Snowflake, the first-day return was 130% where the average in the US was 19% in 2019 (WilmehHale, 2020). Snowflake is an example of a very popular innovative company that creates new technology solutions. Innovation is a way to adapt quickly to the new supply, demand, consumer behavior, and ways of doing business. Something which was important but maybe is even more important now during the Covid-19 pandemic. Top companies in a sector distinguish themselves by consistent innovations that increase their share in the sector. Innovation takes place in every sector, but sectors that are in the top 50 most innovative companies in 2020 are: Technology, consumer goods

& services, Transportation & energy, Healthcare (Boston Consulting Group , 2020). Appendix C provides an in-depth look at world IPO market differences with additional background information.

1.2 Research objective

This research is about the impact of innovation intensity on the underpricing of initial public offerings in Europe. As seen above, there has been a lot of research on IPO underpricing. An IPO occurs when companies issue shares for the first time. We talk about underpricing of an IPO when the closing price on the day of the IPO is higher than the price at which the company makes the shares available for the first time (the offer price) (Ritter, 1984). IPO underpricing results in "money left on the table" for issuing companies, which refers to the lost capital that could have been raised if the shares were offered at the actual value (Ritter & Welch, 2002).

There are different explanations and theories for underpricing (Jamaani & Alidarous, 2019). Most frequently used are the information asymmetry theories. This is also where the relationship between innovation and IPO underpricing is relevant. Innovation can be defined as the creation, development and implementation of a new product, process or service with the aim of improving efficiency, effectiveness or competitive advantage (supported by the government of New Zealand). Theories of information asymmetry are especially relevant to innovative subjects because research and development involves a unique and uncertain nature (Heeley, Matusik, & Neelam, 2009). Next to that, accounting-related information in terms of innovation capital connects to information asymmetry models. All underpricing theories based on information asymmetry assume that underpricing is positively related to asymmetric information (Ritter & Welch, 2002). Therefore, the lower the information asymmetry the less underpricing will exist. Underpricing can be viewed as a premium that is paid to investors for insuring them against the adverse outcome (Engelen & van Essen, 2010).

Innovation is essential for a company when it comes to long-term growth and competitiveness (Vermeulen, 2003). The relationship between innovation and long-term firm value seems clear, but unlike many studies, this one looks at the effect of innovation on short-term, meaning underpricing. The relationship between innovation intensity and the pricing of IPOs is still less clear, and there has been little research on this, particularly in Europe. Innovation is not a fixed variable but an often knowledge-based process. This makes information gathering difficult. When innovation is considered a process, inputs and outputs can be distinguished. Uncertainty about future innovations through R&D investment (input) can be high and the value of innovative firms can be difficult for investors to determine. Aboody & Lev (2000) argued that the unique nature of research and development (R&D) investments makes it difficult for outsiders to learn about the productivity and value of a given firm's R&D from the performance and products of other firms, thereby contributing to information asymmetry. This uncertainty lies in the output it will generate, but also the accounting related rules. Patent information (output) has a more certain image, but patent information does not always provide the sought-after information about value addition or not. So innovation can be very valuable for investors, but because it is uncertain and sometimes incomplete in terms of information provision, it affects information asymmetry. The disclosure of information during the IPO is a difficult issue especially for innovative companies. With a higher informational asymmetry, a higher degree of underpricing often takes place (Ritter & Welch, 2002) which would mean that the positive future effect of innovation is not present in the short term. This is an interesting issue and a potential dilemma for companies. The central question, therefore, is what is the effect of the innovation intensity within a company on the underpricing of IPOs?

Research Question: *What is the effect of innovation intensity on the underpricing of IPOs in European stock market?*

Much research of this topic, the relation of innovation to IPO pricing, has been done in large IPO markets such as US and China. This research focuses on the IPO market of Europe which puts the relationship in a different institutional and regulatory framework. Many studies are based according to general used GAAP accounting regulations, but this research uses International Financial Reporting Standards (IFRS). As measure for the European stock market the Euronext stock markets are chosen. Euronext contains stock markets in Amsterdam, Brussels, Dublin, Lisbon and Paris, making it the largest stock exchange in Europe. This provides a comprehensive general description of the European IPO market for IPOs. This study also does not, unlike many others, focus on a specific sector. There is a wide variety of indicators that is been used for innovation. Unique about this study is the distinction that is made between expensed and capitalized R&D values. This study provides a complete picture of innovation in different sectors.

1.3 Thesis outline

The following sections of the thesis will be structured as follows. Chapter 2 gives background information on initial public offerings. This introduces the process in which underpricing can occur. Chapter 3 is the literature review and describes among others the phenomenon of underpricing. From this follow several asymmetric information theories that explain underpricing in section 3.1.1. 3.2 further discusses innovation and its relationship with asymmetric information using the innovation process. In chapter 4 the hypotheses are formulated and in chapter 5 the methodology is described with the research and regression methods and description of the variables and sample data. Then chapter 6 contains all the information of the data selection and the sample that are used including the descriptive statistics. Chapter 7 describes the results of the quantitative research. Finally, chapter 8 consists of the conclusion and limitations of this research.

2. Introduction to initial public offering

Before describing the theory section on the topic of innovation and underpricing of IPOs, some background information about initial public offering is given. The process of an IPO, section 2.1.1 first describes how an IPO process looks. This provides the background information of the process in which underpricing can arise. This part shows the actions and choices that the company encounters during the IPO process. 2.1.2 Reasons to go public, describes the possible advantages and disadvantages for a company to go public.

2.1 The IPO process

The process starts with the decision to go public. After this decision, the issuer, the firm that goes public, chooses an investment bank that will manage the process on behalf of the issuer. This can be one or more investment banks based on the size of the issue (Katti & Phani, 2016). In the case of multiple investment banks, there will always be one that is the main underwriter and takes the lead during the process. Important factors in making the choices for an investment bank may include the reputation, expertise and quality of research in the specific industry of an investment bank (Ellis, Michaely, & O'Hara, 1999). This underwriter determines a first valuation of the value of the company. This can be based on various methods such as: expected growth, rate for the industry or with valuating of multiples. The use of comparable firm multiples is widely recommended for the valuation of IPOs according to Kim & Ritter (1999). The underwriters also include various macroeconomic indicators and look at industry specific information. (Katti & Phani, 2016)

Underwriting a company can be done in two ways:

- Firm commitment: The investment bank can buy all shares at a discount and then try to resell them. This means that the underwriter bears a lot of risk. The profit for the investment bank is the gross spread which is the difference between the buying value and the selling value of the shares. (Ellis, Michaely, & O'Hara, 1999) (Dunbar, 1998)
- Best effort Basis: The investment bank can also not buy the shares and instead agree with the company on an offering price and a minimum and maximum number of shares to be sold. (Dunbar, 1998)

There are several factors that influence the success and likelihood of success of an IPO. These are the size of the offering, the price, the reputation of the underwriter and the clustering of filings according to Dunbar (1998). Before a company can enter the stock market, the issuing company must prepare an official registration statement with as a part of it the prospectus. In the US, this must be filed with the Security and Exchange Commission (SEC). The European version is the European Securities and Markets Authority (ESMA). The prospectus is a part of the registration statement which will be available for every possible investor and is one of the primary tools in marketing the issue (Ellis, Michaely, & O'Hara, 1999). This document consists of the information already gathered during the previous IPO process steps. Marketing of the IPO takes also place during a road show, a series of presentations given in various locations, where the underwriter can estimate how much interest there is from investors for the IPO. Shares are not officially sold in road shows but orders that are submitted are only indications of interest and used for the determination of the offer price. On the day before the IPO, the offer price of the IPO and the number of shares that will be offered for sale are determined by the underwriter and the issuer. If an IPO is undervalued, the price of the shares can rise on the first day. The underpricing topic is discussed further in section 3.1. The pricing is roughly the same in any country that follows the same pricing process (among others: Book building, auction, fixed price) (Katti & Phani, 2016). After the price is set, the shares are distributed among the prospective investors. The allocation is made based on previous bids. On average, a week after the allocation process, the shares are listed and traded on the exchange. Typically, underwriters sell 115% of the shares they own. Underwriters have the overallotment option to buy additional shares of the company at the offer price later. If the market price goes up, the underwriter earns money with this. If the price goes down, they can buy back shares from the market. (Ellis, Michaely, & O'Hara, 1999). 25 Days after the IPO ends the “quiet period”. Before that, underwriters cannot comment on the value and profit made of the new company. Figure 1 describes summarizes the section above.

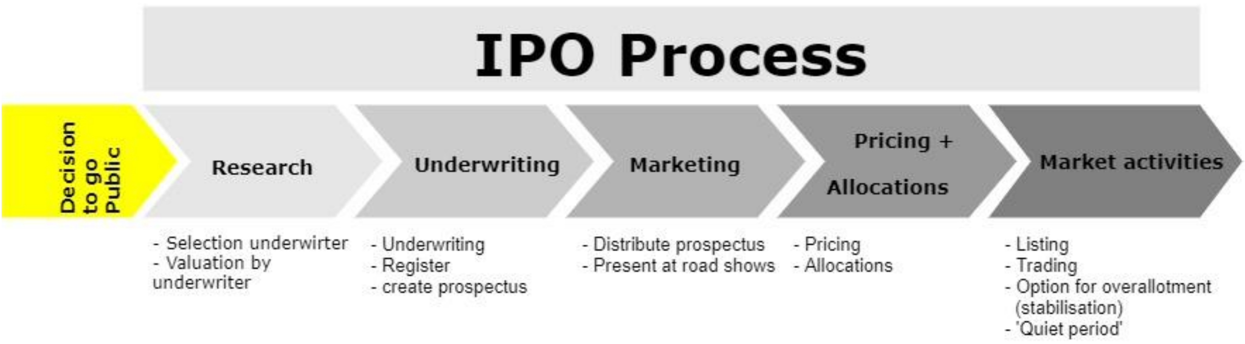

Figure 1: Description of the IPO process based on Ellis, Michaely & O’Hara (1999) and Katti & Phani (2016)

2.2 Reasons to go public

With an IPO, a private company turns into a public traded company. By going public for the first time, a company can raise equity by selling shares. This gives a company access to capital without special risks or restrictions. There are several reasons to do this as a company. The benefits differ per type of company, ownership structure, age and size of the company (Bancel & Mittoo, 2009). According to Ritter & Welch (2002) and Rock (1986), companies may then be looking for money for investments, acquisitions or growth. By going public, it is also possible for initial owners to convert their investments into cash. Next to that it is also a method to reward employees by combining stocks with salary. More equity can also reduce the company's debt-to-equity ratio and the IPO can provide more control over the capital structure. Companies with a large proportion of debt capital are considered high-risk companies (Pagano, Panetta, & Zingales, 1998). An IPO can also have strategic advantages as creating brand awareness, reputation and credibility and improving the company's competitive position (Bancel & Mittoo, 2009). However, the latter has only been proven for IPOs within the EU and not in the US.

The disadvantage of going public is that it creates an obligation for a company to disclose certain private information which can cost the company their competitive advantage. This is especially an important disadvantage for intensively innovative companies because it involves the loss of confidentiality of techniques, policies, and operations. Going public is also an expensive process and there is always the chance that an IPO will partly fail and that the necessary capital will not be raised as a result. There are direct costs such as those of an investment bank, but also indirect costs such as underpricing (Ritter, 1987). In addition, the ownership structure will be supplemented with many new investors. Therefore, profits have to be shared among a large number of new parties. These new shareholders also have certain degrees of control, as a result of which the original owner(s) will face a loss of control.

3. Literature review

In this section, the topic underpricing, underpricing theories and the relationship of innovation to underpricing (theories) are discussed. Section 3.1 describes the underpricing phenomenon that goes along with the IPO process. This is followed by the description of different asymmetric information theories in section 3.1.1 Literature about innovation and IPOs and about innovation and information asymmetries can be found in section 3.2. This literature section will lead to the hypothesis on the research question: *What is the effect of innovation intensity on the underpricing of IPOs in European stock market?*

3.1 Underpricing

When an offering price is determined by the issuer and the underwriter, an IPO is often undervalued. With underpricing the offer price is set lower than the intrinsic value of the shares (Beatty & Ritter, 1986). Underpricing is estimated as the initial return which is the percentage difference between the offer price and the first day closing price (Ritter & Welch, 2002) (Ljungqvist A. , 2007). With underpricing the issuing company accepts leaving “money on the table”. This refers to the lost capital that could have been raised if the shares were offered at the first day closing price (Ritter & Welch, 2002). Previous literature shows that IPOs are often underpriced. In the 1980s, the average first day return on an IPO was 7% and between 1990-1998 it even doubled to an average of 15% (Loughran & Ritter, 2004). Loughran & Ritter (2004) found in their study that between 2001 and 2003 there was a first day return of 12% on average in the US. The previously mentioned Dot-com bubble was also an example of IPO underpricing. This was even an example of a hot issue market. Ibbotson and Jaffe (1975) were the first to write about a so-called hot issue market for IPOs. Hot issue markets are periods when average initial return IPOs are unusually high. Hot issue markets are usually clusters of companies of certain industries or companies in which a certain technological innovation is used (Helwege & Liang, 2001). The number of IPOs in such periods is much higher because companies in that specific sector or industry try to benefit from the high returns. These hot issue markets can be explained by popularity of a market, but also by underpricing theories. Ritter (1984) confirms the existence of these periods in his research. For example, a 15-month hot issue market started in 1980 with an average IPO return of 48% with an average return of 16.3% over 1977 to 1982.

As can be seen above, underpricing occurred frequently in in the past. The question, however, is why does underpricing take place. There are different explanations and theories for underpricing. Jamaani & Alidarous (2019) distinguished in their review of theoretical explanations of IPO underpricing information asymmetry, institutional theories, ownership and control theories and behavioral theories. Information asymmetry is one of the most enduring theories that explains underpricing. Information asymmetry theories particularly are used in studies that look at the influence of innovation on underpricing (see table 1). This is because theories of information asymmetry are especially relevant to innovative subjects because research and development involves a unique and uncertain nature (Heeley, Matusik, & Neelam, 2009). Next to that accounting-related information in terms of innovation capital connects to information asymmetry models. For these reasons, only the asymmetric information models are described here.

3.1.1 Information asymmetry

There are three parties involved with the IPO process: Investors, issuing firms and underwriters. In information asymmetry, there is asymmetric information between these parties (Jamaani & Alidarous, 2019) (Ljungqvist A. , 2007). One party in the process has more or better information than another party. In figure 2 it is shown where the different forms of asymmetric information can arise between the key IPO parties. The following sections describe the information asymmetry theories that cause underpricing.

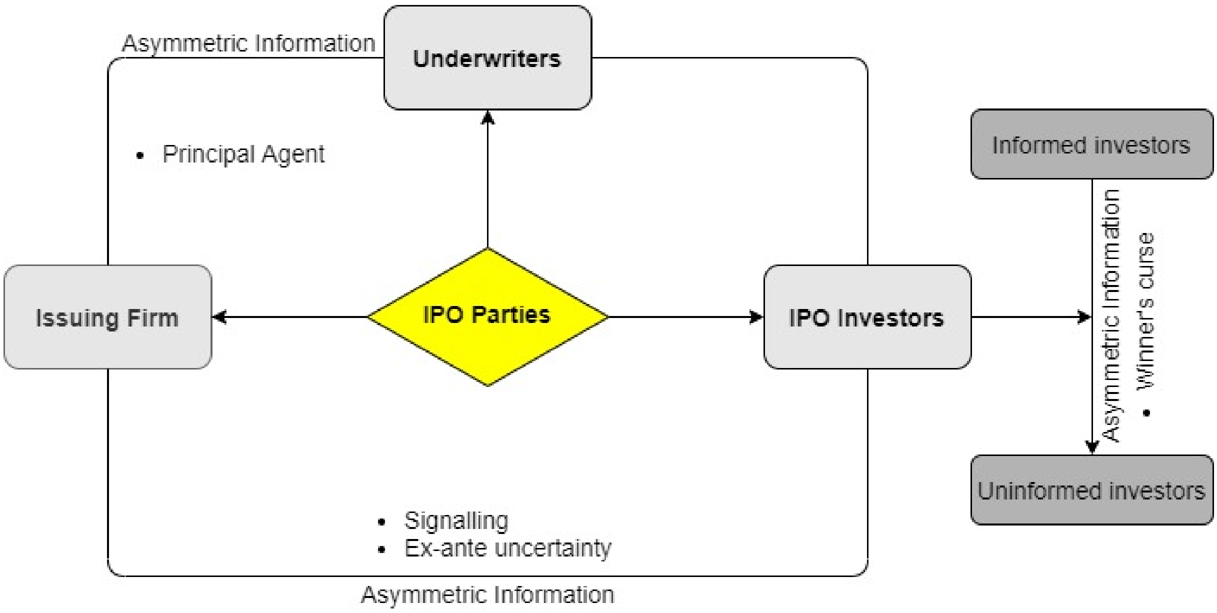

Figure 2 Information asymmetry in IPO parties based on (Jamaani & Alidarous, 2019)

All underpricing theories based on information asymmetry assume that underpricing is positively related to asymmetric information (Ritter & Welch, 2002). Therefore, the lower the information asymmetry the less underpricing will exist. The following theories are the main information asymmetry theories that provide explanations for IPO underpricing.

Signaling

The Signaling theory is about the information asymmetry between issuer and investor (buyer and seller) and is also referred to as the 'lemons problem' (Allen & Faulhaber, 1989). Because investors do not know the real value of a company an investor does not want to pay more than average because he does not want to run the risk of paying too much. Issuing firms can underprice their IPO to send a good signal to investors (Allen & Faulhaber, 1989). Investors can expect a larger initial return through underpricing, thereby the issuing company sends a positive signal about the firm's quality and prospects. A high initial return puts the firm in a good light. The money lost on the underpricing can be recouped by issuing additional shares at a higher price once the IPO hits the market. Low quality companies are not able to make their money back in a seasoned equity offering (SEO) so they will not use signaling (Grinblatt & Hwang, 1989).

Principal agent

The principal agent theory explains underpricing as response to the difference of information between the issuing firm and the underwriter (Baron, 1982). The principal agent theory is a subcategory of moral hazard and can arise when the executive "power" is separate from the owners of the company. In the case of the IPO process, underwriters are held responsible for much of the activity during the IPO process of the issuing party. Therefore, agency problems can arise between the underwriter and the issuing firm (Ljungqvist A. , 2007). Issuing companies want to generate as much revenue as possible and thus need a high price. Underwriters' objective is to have as few shares left as possible. To mitigate this risk, underwriters steer for underpricing (Loughran & Ritter, 2004). Ljungqvist (2007) stated that underpricing represents a transfer of value from the issuing firm to investors and that can lead to rent-seeking behavior. In this way, underwriters can make lucrative deals with investors to have an intentionally low IPO price set. For example, investors may pay the underwriters with excessive trading commissions or low prices may be given in the hope of doing business in the future (Ljungqvist A. , 2007).

Winner's curse

The winner's curse is about the information asymmetry between two types of investors, uninformed investors and informed investors (Rock, 1986). Rock (1986) assumes that in the case of the winner's curse the issuer and underwriter are not as well informed about the real value of the IPO as the investors are. Informed investors only want attractive shares so only bid for the shares where the offer price is lower than the expected true value of the IPO (underpriced IPOs), while uninformed investors bid indiscriminately for all the IPO shares (underpriced and overpriced IPOs). Allocation of shares is usually done pro rata, so in a bad IPO the uninformed investors get all the shares while it is overpriced and the investor is likely to lose money on this (Thaler, 1988). In a good IPO, the uninformed investor has to share the shares with the informed investors so that the value gained is again less than expected. Winner's curse is the problem that arises when uninformed investors get all the desired shares in an unattractive IPO, whereas informed investors get allocations in good IPOs (Hoque, 2014) (Ritter, 2011). Rock (1986) states that the issuer relies from both informed investors and uninformed investors. To ensure the participation of uninformed investors, shares are underpriced to compensate for adverse selection (Ritter, 2011). With underpricing issuers provide a positive return and keep the uninformed investors in the market for initial public offerings.

Ex-ante **uncertainty**

The winners curse theory is extended by the ex-ante uncertainty hypothesis (Beatty & Ritter, 1986). Ex-ante uncertainty is defined as the uncertainty about the intrinsic value of the stock when a firm goes public (Clarkson & Merkley, 1994). More ex-ante uncertainty leads to higher underpricing (Clarkson & Merkley, 1994) (Ritter, 1984). More ex-ante uncertainty about the intrinsic value will mean that the investor is less willing to pay for the shares because the risk is higher. To determine the uncertainty regarding the value of a company, several variables are examined that can create ex-ante uncertainty. For example, company size and age are negatively associated with measures of ex-ante uncertainty (Engelen & van Essen, 2010) (Rock, 1986) (Ritter, 1984). A larger firm that has been around longer has less uncertainty than small young firms. Also, the reputation of the underwriter and market climate can be proxies for ex-ante uncertainty (Clarkson & Merkley, 1994).

3.2 Innovation

In this section, a look into innovation within a company is given. Section 3.2.1 shows the definition of innovation and discusses the importance of innovation in a firm. Section 3.2.2 covers the innovation processes and the measurability of innovation. Section 3.2.3 and 3.2.4 cover the input and output of the innovation process and the measurability of these stages. The measurability of innovation (stages) are important parts in this literature section because the kind of information that innovation variables provide are essential to determining the effect of innovation on information asymmetry (and therefore underpricing). Accounting-related rules and regulations regarding information disclosure are also relevant. In addition, section 3.2.5 further explores what relationship innovation has with information asymmetry.

3.2.1 What is innovation?

The capability of a firm to innovate is one of the most important factors when determining economic growth (Acs, Anselin, & Varga, 2002) (Guo & Zhou, 2016) (Vermeulen, 2003). Especially for companies that enter the stock market, growth opportunities are important. Next to growth, innovation is crucial in order to protect competitiveness (Standing & Kiniti, 2011). Innovations usually generate the opportunity for companies either to develop and introduce new products in the marketplace or to improve production processes (Bessler & Bittelmeyer, 2008). Therefore, innovation can be summarized as the creation, development and implementation of a new product, process or service, with the aim of improving efficiency, effectiveness or competitive advantage (supported by the government of New Zealand).

The economy is increasingly knowledge-based today instead of industry-based in the past. This was stimulated in March 2000 when the political leaders of the EU countries formulated the new strategic goal for the EU as: "… to become the most competitive and dynamic knowledge-based economy in the world." giving the knowledge-based economy a boost (Klomp, 2001). Therefore, the gathering of knowledge is nowadays central to the implementation of innovation. Also, the economy is constantly changing and in a competitive environment it is essential for businesses to be able to adapt and to change to survive.

Differences in innovation

The differences between innovations can be big. Innovation can be seen as change and can occur in many different forms. Tidd & Bessant (2020) divide innovation as change in four areas: product and service (change in the product/ services), process (change in the way of creating and delivering), position (change in the context of offering) or paradigm (changes in underlying mental models). Eveleens (2010) in his literature review makes the difference between product-based, process-based and service-based innovations. In addition to the difference in type of innovation, there are several other dimensions in which innovations differ from each other. For example, the degree of novelty of an innovation which is actually based on the degree of change that goes along with the innovation (Jacobs & Snijders, 2008) (Gopalakrishnan & Damanpour, 1997). Innovations can be incremental or radical.

3.2.2 Innovation process

Innovation can be seen as a complete system or continuous process in the company included in the whole managerial system (Reguia, 2014). There are different types of innovation so also different types of innovation processes. An innovation process can be described as the development and the selection of innovation ideas and the transition into a real innovation (Jacobs & Snijders, 2008). In the literature there are several comprehensive innovation process models described, but many researches state that an innovation process contains the components: The research phase in which ideas are generated and knowledge is combined, the development phase in which ideas are selected and further developed and the realization of the output in which the product is created and implemented (Reguia, 2014) (Bessler & Bittelmeyer, 2008) (Eveleens, 2010). An example of an innovation process model that corresponds to this is the model of the innovation process by Boddy (2011) (figure 3). This innovation model is a generic model that includes the main elements that are also presented in other innovation process models (for example in Eveleen (2010)). Boddy shows the innovation process as if it were a filter in which possible innovations are generated and possibly elaborated. This represents the fact that only a small part of the innovative plans within a company are successful enough to get through the development process.

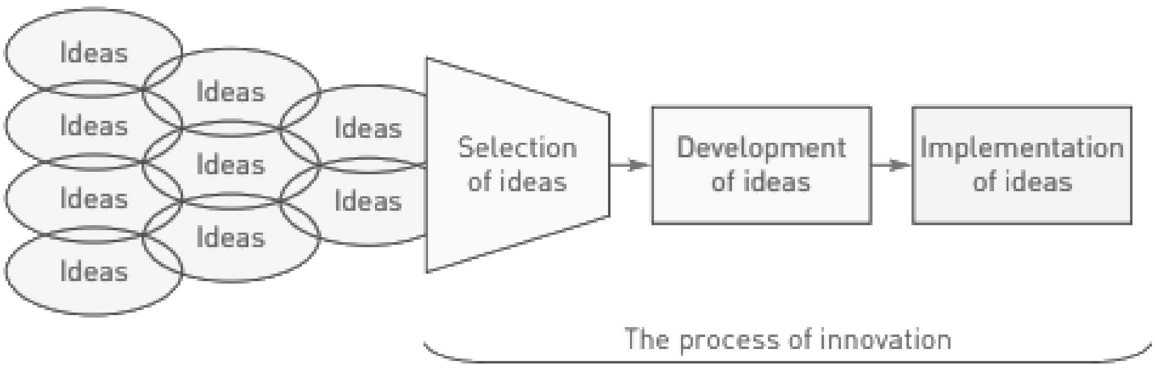

Figure 3: A model of the innovation process (Boddy, 2011)

Measurement of the process

Because innovation is a continuous process, it is usually not directly measurable. There are literature-based innovation output measures that can give a direct indication of innovation, but these are very expensive to produce and only available for several years and countries (Acs, Anselin, & Varga, 2002). In this study, the input-output based model of the innovation process, as described, is used as base for the measurement of the innovation variable. These separated innovation measures are separately available to investors and thus can both have different effects the information asymmetry.

3.2.3 Innovation process input

Combining knowledge and bringing new ideas into the system is very important to create innovations and this is something that takes place in the research department within a company (Tidd, 2011). Knowledge that assists a company to produce products of services can be defined as inputs according to Gopalakrishnan and Damanpour (1997). The most used way in most sectors to generate innovation in a company is investing in R&D (Hall B. H., 2010). This is the start of the innovation process and therefore R&D spending is related to innovative activities. Even though the budget of R&D is often presented together, research and development are two different phases in the innovation process. During the research phase, it is about idea generation and idea selection. These two faces take place after each other. Opportunities for innovation are often discovered by looking for unfulfilled needs (Jacobs & Snijders, 2008). During the selection, the ideas are reduced. This selection is often based on factors such as: chance of success, fit with the company, commercial value (Standing & Kiniti, 2011) (Eveleens, 2010). The development phase is the stage in which selected ideas are further developed and any prototypes can be tested. Steps are also taken to make future innovation usable and producible (Standing & Kiniti, 2011).

Measurement of Innovation input

The level of R&D investment is a reliable sign of innovation activity in a company (Zhou & Sadeghi, 2019). According to Klomp & van Leeuwen (2001), R&D expenditure is the most important input into the innovation process and Kijek & Kijek (2010) confirm this with evidence from EU member states. R&D investments can be made in a certain technology, new capital equipment, but most of all it is invested in researchers and engineers to gain knowledge. In previous studies, the R&D expenditures number is often used as a measure of innovation (input) within a company (Hall B. H., 2010). The reason for this is that R&D is often the only measurement of innovation that has been observed for a longer period and is highly related to innovative activities. R&D investments must be mentioned in the annual financial reports of the companies, so this data is available. The way of representing R&D expenditures can vary, more on this is given in section 2.3.2. However, there are also arguments against the use of R&D expenditures as a measuring instrument for innovation. For example, a higher investment in R&D does not directly mean that this actually leads to more innovation (Klomp, 2001) (Ulku, 2004). Output of the specific investment is usually not definable. For example: Highly educated employees as R&D investment produce immaterial output in the form of knowledge and a part of this can leave when an employee leaves or is fired. Next to that, the success of an R&D investment depends on how a company can turn an invention or technology into something valuable (Zhou & Sadeghi, 2019). R&D investment is a signal for future growth, but at the same time it still involves many uncertainties.

Accounting reporting rules

An important influencer of the uncertainty surrounding R&D are the accounting reporting rules. Providing information in financial reporting can affect the information that financials give. As said in section 3.2.1, different studies found statistical evidence for the negative effect between transparency of accounting information and underpricing (Hopp & Dreher, 2013) (Banerjee, Dai, & Shrestha, 2011).

Investors often make their decision based on financial statements or financial information provided in the prospectus or annual reports. It is very important that this information is reliable, but also relevant. If only a small part of the incurred R&D costs will show up on the financial documents, it is not relevant because it does not say everything about the total. The way these R&D investments are disclosed affect information asymmetry (Aboody & Lev, 2000). If R&D is seen as having future economic benefits (indirect effect) rather than costs, it can be included in a company's balance sheet (capitalization). In that case there are more assets on the balance sheet, which would increase the value of the company. The company's profit will then be higher (on paper). In the case of expensing the R&D expenses are expensed on the income statement. In this case the costs of the company are higher and therefore the company's profit is smaller (on paper). Here, possible valuable forms of output are often left out, resulting in profits that are lower than reality (Lev & Sougiannis, 1996). R&D capitalization contains a lot of interesting information for investors whereas expensing does not say anything about the real future value of the company.

In the US, R&D expenditures are most of the time immediately included in the financial statements as expenses (Chin, Lee, & Kleinman, 2006). Investors get no information about the value and productivity improvement. The relevance of reporting therefore seems low. It can be said that these accounting rules exacerbate information asymmetry. European accounting rules regarding intangible assets according to the IAS (International Accounting Standard). IAS number 38:

- *"Charge all research cost to expense."* (IAS 38.54)

- *"Development costs are capitalized only after technical and commercial feasibility of the asset for sale or use have been established. This means that the entity must intend and be able to complete the intangible asset and either use it or sell it and be able to demonstrate how the asset will generate future economic benefits."* (IAS 38.57)

So, in Europe, a system is used where development expenditures are sometimes included in the balance sheet if they comply with the rules. This is done to promote information disclosure and partially reduce information asymmetry. This difference is related to the difference in accounting standards. In the US the GAAP, generally used accounting principles are used. In Europe (and many other countries outside the US) the International Financial Reporting Standards (IFRS) are used. These measures differ in the way information is prepared and formatted and in methods of how inventory is valued. These measurements also differ in their representation of intangible assets, such as development costs. With IFRS the development costs are capitalized when criteria of future economic benefits are met. As said, under GAAP, development costs are generally expensed. The accounting for R&D costs under IFRS is generally more complex than with GAAP. An issue in with IFRS is that it can be difficult to make the split between research and development for companies (Bogle, 2017). The separate definitions and examples can be seen in appendix F. The distinction between research and development can cause differences and determine when the criteria for capitalization are met can be difficult. This together with the fact that intangible assets are often difficult to determine could reduce reliability. Bowen, Ducharme & Shores (1999) proved that the industry within which a company operates has a significant impact on the accounting choices made by management.

3.2.4 Innovation process output

The output of an innovation process is often a new product or process (Gopalakrishnan & Damanpour, 1997). After the research and development phase the knowledge can be transformed into output. If an idea survived the development stage, the innovation can be implemented and launched. The innovation process model of Boddy (2011) shows the process as a filter which represents the uncertainty factor of the output of innovation investments. Innovation is not easy and it is not a given that investments in innovation will also lead to innovation output (Eveleens, 2010). Only a small part of the innovative plans within a company are successful enough to get through the development process.

Measurement of innovation output

Numbers of innovations are not always available for investors. Therefore patents of innovations are frequently used as an innovation output indicator. A patent is a type of intellectual property that gives the owner the exclusive right of using and selling an invention for a limited period of years. For competitive advantage it is essential that investments in innovation are also protected. A patent can be used to record information and specific characteristics of an innovation together with the owner of the innovation (Lanjouw, Pakes, & Putnam, 1998). In addition, the fact that there is a patent also gives a signal that a patent worthy invention has been made at the company.

A patent provides legal protection of an innovation, allowing the owner of the patent to temporarily use or sell the innovation exclusively. This can improve the competitive position of the company because it stops the competition from copying an invention or developing something very similar (Heeley, Matusik, & Neelam, 2009). Firms with stronger innovation ability can adapt quickly to changes in the market, can quickly generate new knowledge and innovations, and often contain more patents (Zhou & Sadeghi, 2019). According to Zhou & Sadeghi (2019) this works also the other way around: The more patents issuers own, the higher the innovation ability is perceived to be. Therefore, patents can be seen as important intangible assets of the firm. The application of a patent shows that the value of the innovation is larger than the costs of applying for the patent (Griliches, 1989). Next to that, a patent is only granted if the innovation complies with the minimal standards of novelty and utility (Griliches, 1989).

Not all inventions are patentable and not all patentable inventions are patented, but Acs, Anselin & Verga (2002) concluded that the measure of patented inventions provide a fairly reliable measure and represent the innovative activity fairly good. Information about patents is accessible to investors which is important information. Many studies in the field of innovation economics show that patents reflecting technological changes give a significant positive contribution to the value of a company (Hall, Jaffe, & Trajtenberg, 2005). When the focus is on accounting principles when measuring innovation as R&D activity, patents are often ignored (Lev & Sougiannis, 1996) (Guo & Zhou, 2016). This results in the fact that a reliable calculation of income is not always made. The value of the total assets may be greater when measured, resulting in a lower offer price for the IPO. The innovation output variable can be determined by taking the logarithm of the number of patents of a company (Chen & Xu, 2015) (Zhou & Sadeghi, 2019). A possible extension could be to also include the quality/value of patents (Lanjouw, Pakes, & Putnam, 1998). The value of a single patent, however, is often difficult to determine because the patent value is highly skewed (Bessler & Bittelmeyer, 2008). This is because the success rates of R&D and innovations are also highly variable. The difference in patent value may also depend on how early in the innovation process patents are filed. A patent at an early stage of development makes it difficult for competitors to make a similar invention. There are many different methods for measuring the value of patents used in the literature. Scherer and Hardhoff (2000) and Lanjouw, Pakes & Putnam (1998) found significant results for the use of patent age and the number of citations. Patent families, family sizes and IPC classes are also mentioned as indicators. However, the evidence for several indicators is still inconclusive and there were studies where they found no direct relationship between these indicators and patent or firm value (Bessler & Bittelmeyer, 2008). In the study by Lanjouw & Schankerman (2004) who used the number of claims, forward citations to the patent, backward citations in the patent application, and family size as variables the results were not yet uniformly strong.

Overall, it can be said that most studies support the view that the number of patents has a positive effect on firm performance and several other studies support the importance of citation indicators (Bessler & Bittelmeyer, 2008). Hagedoorn & Cloodt (2003) conducted research on measuring innovative performance where they tested multiple indicators among 1200 companies in 4 high-tech industries. They concluded that a composite construct based on the four indicators: R&D inputs, patent counts, patent citations and new product announcements provides a good representation of innovation performance. Their findings also show that the indicators can be used independently as measures of innovative performance due to the presence of statistical overlap. Information on patents is often given in the IPO prospectus.

Patent information

Patents are the innovation output of R&D expenditures and give a clearer picture of the innovation activity within the company than the R&D expenses do. Hall, Jaffe & Trajtenberg (2005) state that non-financial indicators like patent counts contain more information than R&D and that this can be used to assess the market value of R&D activities. The R&D investment is often reported and the number of patents gives a positive signal of the success of this investment.

Since the investment has resulted in an accepted patent and before an invention can be patented, it has to comply with certain rules from, for instance, the European Patent Office (EPO) or comparable, the United States Patent and Trademark Office (USPTO). This gives a company the certainty that a competing company will not be able to copy the invention and explains why the patent count is an accepted variable for the innovation activity of a company. According to the EPO and the USPTO a patent has to be sufficiently described. In exchange for the patent, meaning the exclusive right to the invention, the EPO and the USPTO set specific minimum requirements for the quality and amount of information that must be provided about the invention. For example, it must be clear to those skilled in the art how they could make and apply the invention. The applicant is not allowed to hide the best way to apply the invention that is known at the time of application. In practice, however, this does not yet mean that an investor always gets needed information about the quality of the patent and how it will create value. Patent information is highly technical and often requires a lot of knowledge to understand so it does not give the majority of investors the desired information about, for example, the business aspects (Heeley, Matusik, & Neelam, 2009). It varies from patent to patent whether useful information about the value of the patent to the company for investors is given with the patents. This explains why determining the value or quality of patents is difficult for investors.

3.3 Information Asymmetry and Innovation

Previous studies ((Ritter & Welch, 2002), (Loughran & Ritter, 2004)) show that underpricing of IPOs is common and one of the most referred theories for this is asymmetric information. These information asymmetry theories are based on a difference of information between different parties in the IPO process (Ljungqvist A. , 2007). The degree of innovation within a company is important information for investors because this can increase the growth and value of a company (Vermeulen, 2003) (Acs, Anselin, & Varga, 2002). Innovation is a process in which an input and an output are seen as indicators of the degree of innovation in this study. Accounting standards can influence the effect the innovation input variables on IPO pricing. As an investor you would like to be able to determine the value and value potential of a company as well as possible so that your investment has as little risk as possible.

In information asymmetry between issuer and investor due to the level of innovation, an issuer could underprice its stock to send a signal of quality to the investor and to compensate for the extra risk according to the signaling theory from Allen & Faulhaber (1989). If a higher level of innovation creates a larger gap of information about the IPO process between issuer & underwriter, where there is a greater possibility of agency problems, then it may lead to higher degrees of underpricing according to the Principal agent theory of Baron (1982). With information asymmetry between investors at higher levels of innovation, winner's curse can occur where underpricing occurs to attract both informed and uninformed investors. This is, according to the Winner's curse theory of Rock (1986). In addition, ex-ante uncertainty from Beatty & Ritter (1986) is also an important concept in this case. With additional uncertainty about the value of the company with a higher level of innovation, the ex-ante uncertainty is higher, making underpricing more likely to occur.

3.3.1 Previous research

Previous research based on different institutional frameworks shows different insights. Various studies indicate a different effect from input and output stage occur on underpricing. For example, Chen & Xu (2015) found a weak role of innovation input in IPO pricing and a strong positive effect of innovation output in companies from China. Heeley, Matusik & Neelam (2009) found that R&D investment increases underpricing and the effect of the output is dependent of the transparency of the value in manufacturing firms. Underpricing and information asymmetry is reduced when there is a clear link between the innovation and potential value. Also (Zhou & Sadeghi, 2019) found a result in Chinese firms consistent with these previous studies and consistent with the information asymmetry theory on IPO underpricing. They found significant results that innovation input leads to higher underpricing and higher innovation output results in lower IPO underpricing. Comparing these effects, they found that innovation input has a greater positive effect on IPO underpricing than the negative effect of innovation output on IPO underpricing.

Slightly different results follow in the research of Chen & Shao (2018). They found higher underpricing in companies with higher degree of innovation in terms of patent variables in the US. This questions the role of information asymmetry. These results are similar to those of Chin, Lee & Kleinman's (2006) research on firms from Taiwan. They found that firms with more R&D investment, patent numbers, and patent citations have higher levels of underpricing. The rationale for this is that both R&D investment and patent signatures are seen as value to the firm which drives up the IPO market price. The result suggests that under GAAP investors recognize or perceive value in the information firms provide regarding R&D expenditures, even if they are not on the balance sheet.

Previous research on underpricing has mainly focused on the IPO market in the United States and China. This is not surprising because these are also the leading countries by number of IPOs (see appendix D) (EY, 2020). An area that does not yet appear often in the studies on this topic is Europe. In the next section, hypotheses are used to answer the question that follows from this literature: What is the effect of innovation intensity on the underpricing of IPOs in European stock market?

4. Hypothesis development

This section presents the hypotheses of this study. 4.1 Describes a general part about innovation in combination with asymmetric information. 4.2 Describes what the hypotheses are that fit this study. Hypotheses are made for the innovation variables that are selected in chapter 3: innovation input (Expensed R&D investment and capitalized R&D investment) and innovation output (patents). Also the combination of the two variable groups is studied. A visualization of the studied relationships in this research are showed in figure 4.

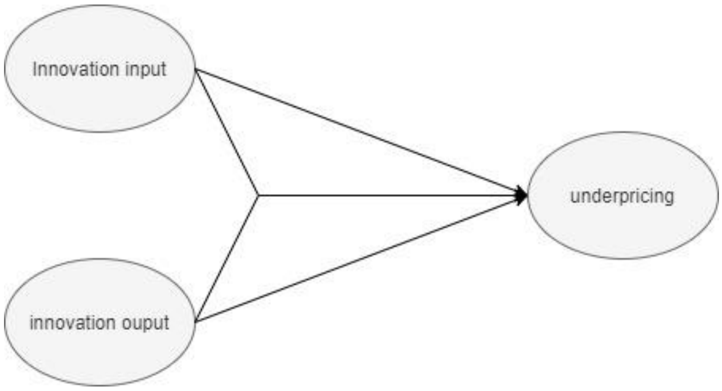

Figure 4: Visualization of the studied relationships in this research

4.1 Innovation and asymmetric information

Looking at the innovation information characteristics, research information is often very confidential in order not to benefit the competition because this could worsen the competitive position (Vermeulen, 2003). Therefore, it can be extra complicated for investors to obtain information about the value of innovation activity (Heeley, Matusik, & Neelam, 2009). In particular for innovative firms, it is assumed that the issuer has better and more information about the market valuation of the firm and the expected performance than investors have (Grinblatt & Hwang, 1989). Therefore, the market of investing in innovative companies looks like the lemons problem / signaling model because of the information asymmetry between the issuer and the investor. As explained in section 3.1.1 this means that issuers will underprice its stock to send a signal of quality to the investor and to compensate for the risk. Additional uncertainty about the value and outcomes of investments in innovation also lead to additional uncertainty about the value of the business. Therefore, ex-ante uncertainty is also an important issue.

Based on section 3.2.2 innovation is seen as a process for which two variables were selected to represent innovation as a process. If the value of the innovation variable ensures that the investor has more information about the (future) value of the company, it reduces the information asymmetry between the investor and issuer. This means that the degree of underpricing will be lower. When the variable provides no information about the value of the investment for the company, this does not reduce the information asymmetry and thus the underpricing. In fact, it can be said here that the uncertainty regarding the value of the firm is greater because costs have been incurred that may not produce growth. This could increase the underpricing. Apart from the value information about the future value addition of an innovation, it may be that just a high value of innovation investment can give a positive signal to investors according to Chin, Lee & Kleinman's (2006). A company can also be highly valued based on investment even though the actual future value addition is unclear.

4.2 Innovation variables and asymmetric information

In this section, the innovation input and output variables will be examined in relation to asymmetric information.

4.2.1 R&D and asymmetric information

R&D investment is a reliable sign of innovation input, but this variable contains uncertainty for the investors about the true value. A high level of R&D expenditures does not always lead to valuable innovation and can hardly be evaluated by the market (Zhou & Sadeghi, 2019). Previous research from Zhou & Sadeghi (2019), Heeley, Matusik, & Neelam (2009) and Chen & Xu (2015) found a positive relationship between R&D and underpricing. In addition, Zhou & Sadeghi (2019) found that the larger the investment, the greater the degree of underpricing. This implies that the higher the level of innovative activity within a company is, the more information is needed for investors to determine the value of the company and the more R&D investment within a company, the higher the uncertainty for investors is. Underpricing arises from greater measures of information asymmetry (Ritter & Welch, 2002) and underpricing can compensate for risk and uncertainty about the value of the business (Engelen & van Essen, 2010). According to the signaling model, the issuer can underprice its stock (and offer a higher return) to compensate the buyer for the risk of an unsuccessful R&D investment (Allen & Faulhaber, 1989). About the institutional differences it was concluded that signaling has a stronger impact on IPO initial returns in civil law countries, as most of the countries in Europe (Sundarasen S. D., 2019) (more information in appendix E). If signaling is a more effective tool, it is also more likely to be used more often. This would again imply that the R&D variable, in line with previous research, has a positive relation with underpricing.

In terms of accounting related information transparency, we need to make a split between expensed and capitalized R&D values. The influence of transparency of accounting information on underpricing is proved by Hopp & Dreher (2013). With expensed R&D costs the justifications as given above by previous research apply. A higher investment in R&D (expensed) affects the degree of uncertainty about the company's value because this investment can turn out to be good or bad. It also affects the information asymmetry. There is more of an additional innovation asymmetry at a higher level of R&D investment in the case of expensing because it is unclear to investors what part of the investment can later be developed into valuable innovation and information asymmetry is increased (Aboody & Lev, 2000). A higher degree of uncertainty and information asymmetry will result in higher underpricing according to the theories. Signaling by underpricing can be used in this case. At the same time innovation investment is seen as a cost so the total costs are generally higher and thus the profit will be smaller (Chin, Lee, & Kleinman, 2006). This causes smaller firm valuation which lowers the offer price which would also increase underpricing. Therefore it is expected that, consistent with the asymmetric information theory and other research, there is a positive relationship between R&D expenditures and underpricing in European IPOs that expense their R&D costs.

Hypothesis 1.1: *The expensed R&D costs level positively influences the level of underpricing in European IPOs.*

Capitalizing R&D costs is obligated under IFRS in the case that future economic benefits are met (IAS number 38). Therefore the increased information asymmetry due to the innovation level is likely to be less about the capitalized R&D value compared with companies that expense their R&D costs. The financial statements ensure that information on the value of innovation is given so that there is less to no additional information asymmetry. The capitalized R&D value shows the costs that are made and led to value creation and therefore could be said that the benefits of signaling will be taken over by capitalized values. However, this value remains a little uncertain because there may be differences between companies in the determination of the criteria before capitalization may take place (Bogle, 2017). Nevertheless, due to the reduction in information asymmetry, the expectation is that the level of capitalized R&D values have a negative relationship with underpricing according to the underpricing theory.

Hypothesis 1.2: *The capitalized R&D costs level negatively influences the level of underpricing in European IPOs.*

4.2.2 Patents and asymmetric information

It follows from previous studies that the relationship between the number of patents and the level of underpricing is negative. Zhou & Sadeghi (2019) argue that the number of patents gives off an important signal to investors which makes investors better able to value the company. This reduces information asymmetry and therefore underpricing. A patent does provide certainty to investors of a successful R&D investment. It shows that the value of the innovation is larger than the costs of applying for the patent (Griliches, 1989). The picture of patents on reduced information asymmetry is in line with the results from Zhou & Sadeghi (2019), Heeley, Matusik, & Neelam (2009), Chen & Xu (2015) and with Chin, Lee, & Kleinman (2006) as well. It is expected that the negative relationship will not be different in Europe because there is no difference in patent information. Therefore, it is expected that more patents within a firm will reduce information asymmetry.

Hypothesis 2: *The number of patents negatively influences the underpricing in European IPOs.*

As described in the literature review, the quality of patents is hard to find. It varies from patent to patent whether useful information about the value of the patent to the company for investors is given with the patents. For some patents, the link between the patent and the value this patent can bring is clear and for others it is not. This can influence the asymmetric information between the issuer and the investor. This attribute of patents is not further considered in this research because there is not enough data available.

5. Methodology

The research investigates the influence of innovation intensity on the initial return and associated underpricing of an IPO. This chapter describes how the hypotheses are tested. To test the hypotheses and answer the main question, this research uses quantitative statistical analysis techniques for which a model will be constructed. This model contains the variables we want to examine to answer the research question. This methodology chapter starts with finding out how the variable underpricing and the variables for innovation can be measured. After that, the method of the research is explained with the use of examples from previous research. This is followed by the description of the actual analysis model and way of analyzing. This is again followed by the sections on the description of the different variables and how they are made measurable.

5.1 Measurement of main variables

5.1.1 Underpricing

Before developing the model to test the hypotheses, the variable underpricing must be measured. Regarding the variables in previous relatable studies about underpricing (Table 1), the dependent variables in previous studies of IPOs often differ depending on the direction of the study: long term effect or short-term effect (underpricing). In the case of the long-term effect of underpricing, the buy-and-hold abnormal return (BHAR) measure is almost always used. This variable is a multiyear return measure and gives the market adjusted difference between compound returns. In this research, the focus lies on the short-term underpricing of the shares of an IPO as dependent variable. The degree of underpricing is also known as the initial return ratio of the IPO (Ritter & Welch, 2002). Short-term underpricing can be measured by the initial return (IR) and the market adjusted initial return (MAIR). These are the most used methods in previous research.

The measure of underpricing as the initial return is consistent with the standard methodology according to Engelen & van Essen (2010). This is the (percentage) change between the offer price and the market price. The initial return is one of the most used methods to measure underpricing, including that of Jay R. Ritter.

$$IR = \frac{P_1 - P_0}{P_0} \; (* \; 100\%) \qquad (1.1)$$

Where:

IR = Initial return
P_0 = Offer price of the IPO stock
P_1 = Closing price of the IPO stock at the end of the first day of trading

An alternative is the market adjusted initial return method from Aggarwal, Leal & Hernandez (1993). This method adds the influence of market dynamics that may have affected the IPO. In the case where the time interval between the offering day and the trading day is long this can be useful because more time passes and there is a larger chance of (larger) market influence on the IPO closing price of the first day trading (Mehmood, Rashid, & Tajuddin, 2021). It can also be useful to be able to compare short-run underpricing calculations with first day closing price and for example second day closing price.

$$MAIR = \frac{P_1 - P_0}{P_0} - \frac{M_1 - M_0}{M_0} \; (* \; 100\%) \tag{2.1}$$

Where:

MAIR = Market adjusted Initial return

M_0 = General market index closing price at the offering day of the stock

M_1 = General market index closing price at the first day trading of the stock

These general market index closing prices can also be replaced by composite indexes.

Several articles argue that MAIR provides a better representation because the market impact is included in the calculation and this is often more appropriate for the datasets of these studies (Zhou & Sadeghi, 2019). However, Engelen & van Essen (2010) say that in the case of a one-day return, there is no significant form of market impact because the first-day IPO return is very large compared to the average market return.

Further in the literature, similar methods can also be found where the natural logarithm of IR or MAIR is taken. In this way the influence on the difference can still be measured, but the relatively large range of underpricing levels can then be seen in a small domain. Original skewed data is transformed into more normally distributed data. This may improve the model fit and the linearity between the dependent and independent variables. Formulas for underpricing using this natural logarithm are used for example in Ljungqvist (1997).

$$IR = Ln\left(\frac{P_1}{P_0}\right) \tag{1.2}$$

$$MAIR = Ln\left(\frac{P_1}{P_0}\right) - Ln\left(\frac{M_1}{M_0}\right) \tag{2.2}$$

The underpricing measurement method will be the ordinary initial return calculation because the data provides the first day closing price which means that market influences will most likely be insignificant according to Engelen & van Essen (2010).

Comparison of relevant papers					
Authors	**Title**	**Main dependent (DV) and independent (IV) variable measures**	**Method**	**Sample and Year**	**Country of industry focus**
(Bessler & Bittelmeyer, 2008)	Patents and the performance of technology firms	DV: Underpricing: - Short-term measured as IR - Long-term measured as BHAR Regression is done with Fama-French model alphas IV: Different patent (quality) factors	Cross-sectional regression analysis (OLS)	90 IPO firms 1997-2002	Germany (Neuer Markt)
(Chen & Shao, 2018)	Innovation quality and IPO performance	DV: Underpricing: measured as IR IV: Categorical innovation quality variable based on the number of patent (citations) CV: A.o. R&D intensity measured as R&D expenses/ Sales	Multivariate regression analysis	6100 IPO firms 1981-2006	United States
(Chen & Xu, 2015)	The roles of innovation input and outcome in IPO pricing	DV: Short-term underpricing measured as issuing P/B and P/V and trading P/B and P/V IV: Innovation input index and innovation output index	Multivariate Regression	75 IPO firms	Bio-Pharmaceutical industry in China
(Chin, Lee, & Kleinman, 2006)	IPO anomalies and innovation capital	DV: Underpricing: - Short-term measured as the natural logarithm of the MAIR. - Long term measured as BHAR IV: Innovation measured as - R&D exp/sales - patent/industry mean	OLS regression	623 IPO Firms 1991- 2001	Taiwan
(Engelen & van Essen, 2010)	Underpricing of IPOs	DV: Underpricing measured as IR IV: No innovation related variables	Hierarchical Linear Modeling (HLM)	2920 IPO firms from 2000-2005	21 different countries
(Guo & Zhou, 2016)	Innovation Capability and Post-IPO performance	DV: Long-term underpricing measured as the BHAR IV: innovation scale and process factors after principal component analysis with a.o. change in R&D expense and change in number of products with patent as variables of the factor scale.	Multivariate cross-sectional regression	151 IPO firms 1991-2012	Biotech firms (From the Global New Issue database)
(Heeley, Matusik, & Neelam, 2009)	Innovation, appropriability, and the underpricing op IPOs	DV: Underpricing measured as IR. IV: Innovation - Innovation input as R&D/sales. - Innovation output log(Patent+1)	Multivariate regression analysis	1413 IPO firms 1981-1998	Manufacturing firms
(Zhou & Sadeghi, 2019)	The impact of innovation on IPO short-term performance	DV: Underpricing measured as the natural logarithm of the MAIR. IV: Innovation measured as - Input: Expenditures/total assets - Output: Log(number of pat)	OLS regression	1460 IPO firms 2009-2016	China

Table 1: comparison of relevant papers of the effect of innovation on IPO underpricing (based on IA)

5.1.2 Innovation

As written in section 3.2.2 Innovation is usually not directly measurable because innovation is a process and not one element. Previous studies sometimes differ in measurement method of innovation. Table 1 provides a comparison of several relevant papers in this research field that use information asymmetry as a theory for underpricing. Some studies use or test innovation process output as an independent variable. Bessler & Bittelmeyer (2008) for example examine the influence of patents (quality) variables on firm performance. Chen & Shao (2018) use a slightly different approach by dividing the data into innovation quality groups based on the number of patents and patent citations for the multivariate regression. However, in this study, we assume the input-output
model of the innovation process as the basis for the innovation process. By using an input and output variable, a better representation of the innovation process is given. This division of the measurement of innovation over innovation input and innovation output more often used including by Chen & Xu (2015) and Zhou & Sadeghi (2019).

5.2 Research Method

In this section the method of the quantitative statistical analysis is described. This starts with a small look at previous used methods in related previous research and is followed by the description of the research method.

5.2.1 Previous used methods in related research

Table 1 shows that similar studies almost consistently use regression analysis (also known as linear regression analysis) to examine the relationship between innovation and underpricing.

Bessler & Bittelmeyer (2008) examine the influence of patents on short term and long-term underpricing. They use cross-sectional regression to find out which patent (quality) variables have a significant influence. They use the Fama-French model to correct for common valuation factors. Other studies use control variables for this purpose. Chen & Xu (2015), Chin, Lee & Kleinman (2006), Guo & Zhou (2016), Heeley, Matusik & Neelam (2009) and Zhou & Sadeghi (2019) all use multivariate regression analysis too. These studies do not distinguish between different groups or countries in their way of analyzing. Chen & Shao (2018) use a slightly different approach by dividing the data into innovation quality groups based on the number of patents and patent citations for the multivariate regression. They try to make a difference between companies without patent data and companies without patents.

5.2.2 Multiple Regression

The purpose of regression analysis is to examine the relationship between the dependent and independent variables. In linear regression, there may be one or more independent variables. Simple regression is used when the effect of an independent variable on the dependent variable is tested. When the relationship of multiple independent variables are tested on the dependent variable we speak of multiple regression analysis. In the case of this study, there are multiple independent variables so multiple regression analysis is used.

Regression analysis can also differ in other areas than by the number of independent variables in the model. For example, there is a difference between logit and linear regression. Logit regression requires a binary variable. Linear regression requires metric variables. This study contains metric variables and therefore the Linear multiple regression analysis is sufficient for this study. Multiple linear regression is the most widely applied statistical technique for relating two or more variables (Jobson, 1991).

The dataset which is used contains cross-sectional data. That means that de data is collected at the same point of time. Multiple regression as an appropriate method for this sort of data. possible extensions of the model will be set depending on the assumptions.

5.3 Regression Method

The main objective of this study is to see if the innovation intensity (innovation input and output) affects the measure of underpricing of IPOs. As explained in the previous part, a multiple linear regression model is used to test the hypothesis. This is done with a measure of underpricing as the dependent variable and measurements of innovation input and output as independent variables. This section shows the model that is used to do the regression analysis. A select number of control variables that can have influence on de dependent variable are included in the analysis (see section 5.4). As hypothesis 1.1 and 1.2 show there are two different types of R&D values. To do the analysis, we do two different regressions. These regressions are done with the same sample, but with another variable as R&D value. Model 1 contains the expensed R&D value as innovation input variable, where model 2 contains the capitalized R&D value as innovation input variable. For testing the effect of the R&D intensity (H1.1, H1.2) and the effect of the number of patents (H2) on underpricing equation 1 is used in the two different variables:

$$IR_{i,t} = \alpha + \beta_1 R\&D_{i,t} + \beta_2 NrPat_i + \beta_3 CV + \varepsilon \qquad (1)$$

Where in case of the model 1 the equation 1.1 is used and in case of the model 2 the equation 1.2 is used:

$$IR_{i,t} = \alpha + \beta_1 R\&DEXP_{i,t} + \beta_2 NrPat_i + \beta_3 CV + \varepsilon \quad (1.1)$$

$$IR_{i,t} = \alpha + \beta_1 R\&DCAP_{i,t} + \beta_2 NrPat_i + \beta_3 CV + \varepsilon \quad (1.2)$$

Where:

$IR_{i,t}$= Initial return of company i at time t
α= Constant
$R\&DEXP_{i,t}$= R&D intensity of company i at time t
$R\&DCAP_{i,t}$= R&D intensity of company i at time t
$NrPat_i$= Number of patents of company i
CV= Control variables ($Age_{i,t}$, $Size_{i,t}$, $Volume_{i,t}$, $Leverage_{i,t}$)
$\varepsilon_{i,t}$ = random error term

The dependent variable underpricing is measured with the initial return of company i at time t. Innovation input is measured by the R&D intensity that is given as expensed costs in model 1 and capitalized costs in model 2 of company i at time t. Innovation output is measured by the current number of patents of company i because the data does not allow a calculation with data at time t. Therefore, it is assumed that the current number of patents is a full indicator of the overall degree of innovation or innovation output of a firm. This assumption can be made because patents last for several years and therefore the numbers per adjacent years do not vary enormously. The regression controls for different variables: Company age ($Age_{i,t}$), Size of the company ($Size_{i,t}$), Trading volume of the IPO ($Volume_{i,t}$) and Leverage of the IPO firm ($Leverage_{i,t}$). In addition, $\varepsilon_{i,t}$ is the error term.

With the regression analysis the unknown parameters of the equation are estimated. The results in the form of parameters give an indication of the effect of the independent variables. According to hypothesis 1.1 the effect of innovation input on underpricing is given by parameter β_1 and this parameter is expected to show a positive sign for model 1 which would imply that expensed R&D value increases information asymmetry and thereby underpricing. A negative sign for the same parameter β_1 in model 2 is expected according to hypothesis 1.2 which would imply that capitalized R&D value decreases information asymmetry and underpricing. Next to that β_2 shows the effect of the number of patents on underpricing and this value is expected to be negative. This would mean that the higher the number of patents is, the lower the level of information asymmetry and underpricing.

5.4 Variables

In this section, the measurement of the independent variables and control variables that are included in the regression models are explained. The estimation of the dependent variable underpricing is explained earlier in this chapter. Some of the variables are largely skewed. To increase the model fit the data can be transformed into a more normalized variable by using the natural logarithm. The measurement methods of prior research were considered for the application of the natural logarithm.

5.4.1 Independent variable

The independent variable represents the measures of innovation within a company. In this study, we use an input and output variable of the innovation process to measure the innovation intensity of a firm. Section 2.3.1 and 5.1.2 substantiated this.

R&D expenditures ($R\&DEXP_{i,t}$ and $R\&DCAP_{i,t}$)

R&D expenditures cannot simply be compared with each other because this says nothing about the R&D intensity of the company. The size of the company would have a big influence on the value. R&D investment can be measured by the ratio of R&D expenses over revenue (Jefferson, Huamao, Xiaojing, & Xiaoyun, 2006) or with R&D expenses over total assets (Zhou & Sadeghi, 2019). In this way, the R&D intensity can be compared with that of other companies. Revenue values in the data, several times shows values of 0 which makes data unusable in these cases. Therefore, the measurement for R&D expenditures is taken as R&D expenses over total assets:

$$R\&D_{i,t} = Ln\left\{\frac{R\&D\ Expenses}{Total\ Assets}\right\}$$

R&D expenses can be expensed or capitalized. In the equation, the expensed or capitalized values can be implemented depending on the use of sample 1 or 2.

Number of patents ($NrPat_i$)

With the number of patents the output of the innovation is given. In line with previous studies ((Heeley, Matusik, & Neelam, 2009), (Chen & Xu, 2015), (Chen & Shao, 2018) and (Zhou & Sadeghi, 2019)) the variable number of patents are transformed before used in the regression. The number of patents are measured as the natural logarithm of the number of patents. $Ln(1) = 0$ and therefore, we add one patent to every patent count. For the number of patents, the number of patents stated in the IPO prospectus are used.

$$NrPat_i = Ln(number\ of\ patents + 1)$$

5.4.2 Control variables

In this research the purpose is to measure the impact of innovation variables on the level of underpricing. Next to the independent variable, other variables have an effect on underpricing. A few of these are included as control variables. In total there may be thousands of factors affection underpricing (Zhou & Lao, 2012). This section lists the a few factors mentioned in rich empirical IPO literature (Engelen & van Essen, 2010).

Firm Age ($Age_{i,t}$)

Ex-ante uncertainty is generally lower for firms with a higher age (Ritter, 1984) (Rock, 1986). Younger companies have more uncertainty about the value of the firm and therefore investors want more underpricing for these younger companies (Engelen & van Essen, 2010). The longer a company exists, the more history it has and the more information and financial data it has (Loughran & Ritter, 2004). The firm age at year of the IPO is a control variable in line with Heeley, Matusik & Neelam (2009) and Chen & Shao (2018).

$$Age_{i,t} = Ln(company\ age\ at\ IPO + 1)$$

Firm Size ($Size_{i,t}$)

Larger companies signal for stability and an increase in the company will reduce the uncertainty on viability, thus reducing the size of underpricing (Heeley, Matusik, & Neelam, 2009). Next to that, larger firms are expected to have less information asymmetry (Zhou & Sadeghi, 2019).

To control for the positive effect of the firm size with underpricing, the variable total assets will be used. The natural logarithm of the total assets in the year of the IPO is used following Heeley, Matusik & Neelam (2009) and Zhou & Sadeghi (2019).

$$Size_{i,t} = Ln(Total\ Assets)$$

Trading Volume ($Volume_{i,t}$)

In line with Zhou & Sadeghi (2019) the natural logarithm of the volume of the IPO is implemented as control variable. Firms with higher trading volume can indicate that investors are optimistic about the issue. Therefore an negative relation with underpricing is expected.

$$Volume_{i,t} = Ln(IPO\ trading\ volume)$$

Leverage ($Leverage_{i,t}$)

Leverage is often used by investors to determine the health of a company. A lower level of leverage indicates less financial risk because of external financing. This would increase underpricing. In line with the research of Chen & Shao (2018) leverage is included as a control variable.

$$Leverage_{i,t} = \frac{Total\ Debt}{Total\ Assets}$$

Leverage also has an effect on innovation within a company:

Singh & Faircloth (2006) examined the relationship between financial leverage and R&D expenditures in the US and found a strong negative relationship. Research intensive firms tend to contain less leverage because R&D investments lead to intangible knowledge in the form of human capital. Debt repayment requires a stable source of cash flow where physical assets are preferred making it difficult to find finance for an R&D investment (Hall B. H., 2010). Czarnitski & Kraft (2009) also studied this topic among German manufacturing firms with patents as innovation measure. Their results also shows that debt financing has a negative influence on innovativeness. It is expected that firms with a lower level of leverage tend to make higher R&D investments and have a higher number of patents.

6. Data

This chapter describes the data that is used for the regression analysis. The sample consists of IPO firms between 2011 and 2021. In 6.1 the sample collection is described. Section 6.2 outlines the sample composition.

6.1 Sample collection

The effect of innovation on the underpricing of IPOs in Europe is investigated in this study. Therefore, a selection was made in Orbis for an appropriate dataset. Orbis is a database from Bureau van Dijk specialized in financial information. One of the selection criteria includes the stock exchange of the IPO. The most previous studies carry out their research with data from companies in China or the US. This research is conducted over the region of Europe. As data for the European IPO market, the IPOs of the Euronext exchanges are used. Euronext is the largest stock exchange in Europe and brings together the exchanges of several major cities in Europe: Amsterdam, Brussels, Paris, Lisbon, Dublin, Oslo. This market was originated in 2000 from the fusion of three stock exchanges: Amsterdam, Brussels and Paris. This sample makes it easier to make comparisons between companies depending on the context of the observations and independent of stock exchange characteristics. This selection within Europe was also made because a lot of data had to be searched for separately.

The companies as observations are selected from the database Orbis with the selection: Completed IPO target firms on Euronext exchanges in the period from January 2011 till January 2021.

The further data for this research is gathered from different sources. Specific data on this company selection is extracted from both Orbis and Refenitiv Eikon and some variables are double-checked in with data from the website Market Watch. There is and disadvantage of using a secondary data source, which Orbis and Refenitiv are, because there is no control over the quality of the data. However, Orbis and Refenitiv are specialized in financial data collection and therefore relatively reliable. To increase reliability, a number of variables were measured twice and a number of observation variables were checked using annual reports. Table 2 shows the source from which each variable was taken.

Data	*Used for variable*	*Source*
Company name		Orbis
Offer price	$IR_{i,t}$	Refinitiv Eikon + Market Watch
Closing price	$IR_{i,t}$	Refinitiv Eikon + Market Watch
R&D value Expensed	$R\&DEXP_{i,t}$	Refinitiv Eikon
R&D value Capitalized	$R\&DCAP_{i,t}$	Refinitiv Eikon
Number of patents	$NrPat_i$	Orbis and EPO
Total Assets	$Leverage_{i,t}$, $R\&DEXP_{i,t}$, $R\&DCAP_{i,t}$, $Size_{i,t}$	Refinitiv Eikon
IPO Volume	$Volume_{i,t}$	Refinitiv Eikon + Market Watch
Firm age	$Age_{i,t}$	Google + Orbis
Total Debt	$Leverage_{i,t}$	Refinitiv Eikon

Table 2: Data collection sources

The offer and closing price are double checked in the two sources Refinitiv Eikon and Market Watch and this also applies to the IPO volume. R&D expenditure values were given by Orbis and Refinitiv. Orbis showed only expensed R&D values but with comparing these with expensed values from Refinitiv and annual reports the reliability of the Orbis values were found to be relatively low. Therefore, Refinitiv was chosen as data source for R&D values. These values were checked for several companies with the values shown in annual reports and these proved to be the same. For every company the available R&D values of the income statement and the balance sheet are taken. In the case of total assets and total debt, a value from both Orbis and Refenitiv Eikon was available and it was decided to use the values from Refenitiv Eikon for the same reliability argument as the choice for the R&D values. This choice also has the advantage that the same source is used for the financial data. Firm age was measured by taking the difference between the company's start-up date which was founded on google and its IPO date from Orbis.

Patent data is data which is taken from Orbis and from the European Patent Office (EPO). Orbis patent data is given as the number of publications in the section patents. The EPO patent data is given as the number of patent applications. To contain the EPO patent data, a MySQL code is written which can be seen in appendix G to contain the top 100.000 European companies based on number of patents (which ended at the value 1) from 1990 till 2020. Not all companies of the sample could be found in this EPO dataset. For those values that were not present in the selection of EPO values made, it is assumed that they do not have patents and they have therefore been given the value 0. Looking at the patent data from the EPO and from Orbis, these two databases do not fully correspond to each other. Table 3 shows de descriptive statistics of these two sets. in this table the difference of the level of the values are very different. Previous research from Heeley, Matusik & Neelam (2009) found a mean number of 6 patents per observations. Zhou & Sadeghi (2019) found a mean value of 70 patents per company in China which they reported as high in comparison to researches of other markets. Considering this, the choice was made for the patent data of the EPO.

Patent statistics

	N							
	Valid	Mean	Median	Std. Deviation	Skewness	Std. Error of Skewness	Minimum	Maximum
Number of patent applications EPO	115	13.35	4.00	21.364	2.618	0.226	0	111
Number of patent publications Orbis	115	231.78	94.00	424.402	3.933	0.226	1	2597

Table 3: Comparison of patent statistics from EPO and Orbis

6.2 Sample composition

Some adjustments need to be made on the data so that a reliable sample emerges from it. First, Incomplete observations whose important variables or whole companies are not available in Refinitiv were removed from the sample (-29). Of this number were 18 observations of which specifically the price values were not available. Next to that, consistent with prior research no firms with an offer price below $5 are included to prevent fraud and abuse of penny stocks (-7). Further, in line with other studies regarding underpricing of IPOs, companies in financial industry (NACE section K) are deleted from the sample (-5). The total sample resulting from this exercise consists of 115 firms. The numbers and proportion of the total are shown in Table 4 and 5.

City	Amsterdam	Brussels	Dublin	Lisbon	Paris
Number IPOs	14	14	0	0	87
Percentage	12.2%	12.2%	0.0%	0.0%	75.7%

Table 4*: Sample composition countries*

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number IPOs	5	8	12	20	19	13	12	13	9	4
Percentage	4.3%	7.0%	10.4%	17.4%	16.5%	11.3%	10.4%	11.3%	7.8%	3.5%

Table 5*: Sample composition IPO year*

The sample consists for the most part of companies listed on Euronext Paris. IPOs from Dublin and Lisbon have been removed with the adjustment of the data. The sample contains a number of IPO companies from each year from which the sample originates, with the largest number following from 2014. The subsample of maintenance firms in the sample consists of 43 companies, 19 of which are in the complex industry and 24 in the discrete industry.

Before doing the various analysis, it is important to see if the data meets various requirements so that it is possible to draw conclusions from the analysis. For doing multiple regression analysis, it is important to have a touring sample size. According to Henseler (2019), a regression can only be effective at a sample size of 50-100. The minimum depends on the ratio of observations to independent variables. 5 to 1 is sufficient but 20 to 1 is preferred. This sample meets this requirement.

7. Empirical results

The empirical results chapter analyzes the results of the tests to investigate the influence of innovation on underpricing of IPOs, using the information asymmetry theory. 7.1 shows the descriptive statistics of the data set of the research. In section 7.2 the correlation matrix can be found and section 7.3 shows the results of the regression analysis. This is followed by the robustness check which contains some expanding analyses in 7.4. This chapter is closed with the discussion of the results in 7.5.

7.1 Descriptive statistics

Table 6 shows the descriptive statistics of the variables in the sample without transformations.

Descriptive statistics

Variables	N	Mean	Median	Std. Deviation	Minimum	Maximum
Dependent variable						
$IR_{i,t}$	115	0.130%	-0.701%	11.864	-17.725%	77.258%
Independent variables						
$R\&DEXP_{i,t}$	115	74.945	7.880	121.479	0.000	771.208
$R\&DCAP_{i,t}$	115	42.734	0.000	112.545	0.000	652.136
$NrPat_i$	115	13.350	4	21.364	0	111
Control variables						
$Leverage_{i,t}$	115	0.241	0.161	0.253	0.001	1.228
$Age_{i,t}$	115	30.174	12	51.810	0	440
$Volume_{i,t}$	115	1688815.826	81690	5512841.339	300	50530077
$Size_{i,t}$	115	612690.536	46110.000	1712070.272	2549.400	10028980.000

Table 6: Descriptive statistics

After the data selection, 115 observations remained in this dataset. The dependent variable underpricing is measured by the initial return. On average over the entire sample there is slight underpricing of 0.130%. However, the median is negative (-0.701%) which indicates that there are more observations dealing with overpricing than underpricing. There are 70 observations with a lower market price after the first day on the market, 7 observations with an equal market price and 38 observations with a higher market price. However, the mean of underpriced companies is higher (8.16%) than the mean of overpriced companies (4.21%) so that the full sample shows on average a slight underpricing of 0.13%.

Regarding the Expensed and Capitalized R&D values, several times there were no values shown in balance sheet or income statement. In total, 71.3% (82) of the sample conducted R&D in the IPO year (59.13% (68) on the income statement, 36.52% (42) on the balance sheet and 28.7% (33) not). So, despite the regulations, it appears that still the majority of the companies expands rather than capitalize their investments in R&D. In terms of innovation output, there are 77 companies that have patents according to EPO. The average number of patents of companies that did have patents (so excluded values o 0) is 19.94 patents where the overall average is 13.35 patents.

The control variables are also measured in their original value. The variable leverage has a mean of 0.241 and a median of 0.161 which shows that the biggest part of the IPOs has a below-average value. Age, volume and size also has a higher mean than median so higher company values of these variables are clustered into a small group of IPOs.

7.1.1 Transformations and modifications

The figures in section 1 of appendix H show the normal curves of the variables in the histograms. The variables number of patens, IPO volume, size and age are transformed to account for skewness by using the natural logarithm of the variable. This is in line with previous research. Section 2 of appendix H shows the results of the assumption tests for the regression analysis. Based on these results is decided to also transform the R&D variables with the natural logarithm. After the transformations all continuous financial variables are winsorized to account for some large outliers in the data which is also done in prior research (Chen & Shao, 2018). The observations in the 5th and 95th percentile are replaced by minimum/ maximum value at the threshold. By winsorizing, the influence of outliers in the data is minimized, but at the same time this can cause a bias. However, the bias is less than with simply deleting outliers. Before analyzing the descriptive statistics the histograms of the variables are inspected. The new sample and these transformed variables are used in this further research.

7.2 Correlation Matrix

With the Pearson correlation matrix, the pairwise correlations between all the variables of the model are analyzed. This is done with the transformed variables based on the assumption tests in appendix H. The correlation matrix is a result of an univariate analysis and therefore the correlation results do not control for differences in volume, size, leverage or age. The Pearson correlations are presented in table 7.

The results show that the initial return variable has a negative relation with the expensed R&D ratio (-0.147) and a small positive relation with the capitalized R&D value (0.039). This implies that an expensed R&D investment leads to a smaller initial return and therefore in overpricing. Capitalized R&D would result in a small level of underpricing. A small negative relation between the Initial return and the patent variable is found (-0.023) which implies that a higher number of patents would mean that a slightly lower level of underpricing can be expected. The direction of the expensed R&D ratio

Correlations

	$IR_{i,t}$	$R\&DEXP_{i,t}$	$R\&DCAP_{i,t}$	$NrPat_i$	$Volume_{i,t}$	$Size_{i,t}$	$Leverage_{i,t}$	$Age_{i,t}$
$IR_{i,t}$	1.000							
$R\&DEXP_{i,t}$	-0.147	1.000						
$R\&DCAP_{i,t}$	0.039	-0.229**	1.000					
$NrPat_i$	-0.023	0.377*	0.063	1.000				
$Volume_{i,t}$	0.155	-0.053	-0.023	0.027	1.000			
$Size_{i,t}$	0.125	-0.235**	-0.131	-0.122	0.671*	1.000		
$Leverage_{i,t}$	0.080	-0.215**	-0.101	0.017	-0.062	0.091	1.000	
$Age_{i,t}$	-0.016	-0.367*	-0.097	-0.283*	0.340*	0.545*	0.116	1.000

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlation matrix

and the capitalized R&D ratio correlations with the initial return are not in line with the hypotheses. The result of the patent variable is but all three of the mentioned results are far from significant. Taking this insignificance into account, all the above results are not as expected based on the literature.

The correlation between the expensed R&D ratio shows a negative significant result (-0.229) with the capitalized R&D ratio which implies that when the expenditure value is lower, the capitalized value is higher. This is not surprising because the most companies have an expensed R&D value or a capitalized R&D value and therefore has a value of zero for the other investment ratio variable. In the multivariate analysis these variables are not used in the same model. The Expensed R&D ratio and the number of patents variable have a significant and positive correlation (0.377) at a 99% confidence level. Companies with higher expensed R&D cost generally have a higher number of patents. This is in line with the innovation process as mentioned in figure 3. The capitalized R&D ratio also shows a small positive correlation (0.063) with the number of patents but not significant. This can be because 73 of the observations do not have a capitalized value.

Looking at the control variables, the initial return has small positive correlations with IPO Volume (0.155), size (0.125) and leverage (0.080) which means that the initial return is generally higher with higher IPO volumes, larger companies and a higher value of leverage. Age and Initial Return show a negative correlation (-0.016). The relation of leverage and age with the initial return is in line with expectations, but the relations of IPO volume and size are not in line with expectations and results of previous studies. Important note again is that the results are not significant. It was not expected that none of the control variables had a significant correlation with the underpricing variable. In contrast to this, there are significant negative correlations between the expensed R&D ratio with age (-0.367), leverage (-0.215) and size (-0.235) which means that expensed R&D ratio values are generally lower in older and larger companies and in companies with a high leverage level. This last result is in line with the findings from Singh & Faircloth (2006) who stated that research intensive firms tend to contain less leverage because R&D investments lead to intangible knowledge in the form of human capital. The R&D variable is measured by dividing the R&D investment by the size of the company. This is done to scale the R&D investment. Based on these results it can be said that R&D investments do not grow proportionally to the growth in size of the company. However, it is also not strange that in young companies more innovation takes place because a stable position in the market has yet to be achieved. Size and age of a company often increase hand-in-hand which is supported by the significant high positive correlation between these variables (0.545). This explains the same correlation with age and expensed R&D as with size and Expensed R&D. The significant negative relation with leverage is according to the expectations based on Singh & Faircloth (2006). Research intensive firms tend to contain less leverage because R&D investments lead to intangible knowledge in the form of human capital.

The capitalized R&D variable has the same directions of correlation with the control variables as expensed R&D had. There are no significant results but that can because of the data as explained earlier. Regarding the innovation output variable, only a significant negative correlation (-0.283) between age and number of patents was found. It is surprising that younger companies often have more patents, while obtaining an innovation and a patent is often a process that takes a long time.

Furthermore, several other significant results can be seen between the control variables. IPO volume and company size are strongly correlated (0.671). Larger companies often enter the market with a larger IPO volume. Companies with a larger IPO volume are also often older companies can be concluded from this research (correlation of 0.340).

Next to the correlations between the variables, the correlation matrix is also used to look for the level of multicollinearity between the variables. This can affect the reliability of the results. As was also concluded in appendix H the correlation table contains no correlations larger than 0.7. Therefore, no problem with multicollinearity is found in this data set.

7.3 Multivariate regression

With multiple regression the relative contribution of the independent variables to the variance in the dependent variable can be explained. This section describes the results of the analysis that was described in the research design of the methodology chapter. The regression analysis is separated in two models. As explained earlier, model 1 shows the results where the expensed R&D ratio is included as innovation input variable. Model 2 shows the results where the capitalized R&D ratio is included as innovation input variable.

The R-squared value of model 1 is 0.068 which means that the model describes only 6.8% of the variation in the initial return. The model is not statistically significant (P-value of 0.258) and therefore it cannot be concluded that the coefficient is not equal to zero. The R-squared value of model 2 is 0.048 and this model is also not statistically significant with P-value of 0.488. The results of the multiple regression analysis is shown in table 8. The numbers in the table show the Beta coefficients of the regression. Below the beta coefficient values the t-values are given. The t-value is used to create the confidence intervals with which the significance is calculated.

Results of Regression Analyses of the Initial Return

Variable	Model 1	Model 2
$Constant$	-3.127 (-1.140)	-4.790*** (-1.775)
$R\&DEXP_{i,t}$	-0.306 (-0.546)	
$R\&DCAP_{i,t}$		0.112 (0.576)
$NrPat_i$	-0.011 (-0.038)	-0.162 (-0.572)
$Volume_{i,t}$	0.296 (1.309)	0.262 (1.146)
$Size_{i,t}$	0.148 (0.441)	0.216 (0.637)
$Leverage_{i,t}$	1.331 (0.706)	1,981 (1.055)
$Age_{i,t}$	-0.788 (-1.528)	-0.609 (-1.194)
R-Square	0.068	0.048
Adjusted R-Square	0.16	-0.005
F Value	1.311	0.914
Number of Observations	115	115

* p<0.01, **p<0.05, ***p<0.1

Table 8: Regression results

The regression models do not seem to contain any significant relationships. Based on the results, it can be said that the degree of innovation within a company does not influence the underpricing of an IPO. The individual results in the table are discussed in more detail below.

The constant is the slope coefficient. This value is not significant for model 1 (p=0.257) which means that the constant is not different from zero. Also, the further results of model 1 are not significant. The direction of the relationship between the variables is not different from the correlation results. The Expensed R&D ratio again shows a negative result of -0.306 (p=0.109) where this was expected to be positive according to hypothesis 1. Although the result is not significant the information asymmetry theory does not seem to apply in this case.

The constant value in model 2 is significant at an 90% level with P=0.079 which tells that the constant is different from zero. Except of the constant no other significant values can be found. The capitalized R&D ratio shows a positive relation of 0.112 (p=0.566) in the regression. Just like in the correlation table this is not in line with the hypothesis based on the information asymmetry theory. The information of capitalization does not decrease underpricing where expensed R&D investments can according to the results of model 1.

In case of the patent variable, it shows a small negative relation of -0.011 (p= 0.969) in model 1. In model 2 the relation is also negative with -0.162 (p=0.569). This negative relation is in line with the hypothesis that the number of patents negatively influences the level of underpricing. It is also in line with results from previous research from Zhou & Sadeghi (2019) and Heeley, Matusik & Neelam (2009). Although this relation is weak in relation to the R&D ratio variables and that was not expected.

It is remarkable that no clearly differentiated effects between innovation input and output can be seen on IPO underpricing. In addition, expensed R&D investment plays a more pronounced role than patent variable. The fact that the expensed R&D investment reduces the underpricing is not in line with Zhou & Sadeghi (2019) and Heeley, Matusik & Neelam (2009).

Looking at the control variables, in both models, positive values from volume (0.296 with p= 0.193 and 0.262 with p=0.254), size (0.148 with p=0.660 and 0.216 with p=0.526) and leverage (1.331 with p= 0.482and 1.981 with p=0.294) result from the regression. These variables are positively related to the initial return ratio. This is against the expectations that IPO volume and size would have a negative effect on the level of underpricing in line with Zhou & Sadeghi (2019). Consistent with the expectations is that the age variable is negatively related in both models (-0.788 with p=0.130 and -0.609 with p=0.235) which confirms that underpricing will be lower in firms with a higher age.

7.4 Robustness tests

To increase the reliability of the results, a few additional checks and analyses are added to the analysis in this robustness test section. The study already uses multiple variables to measure innovation within a firm are used. In addition, R&D expenditures also distinguish between expensed and capitalized values to measure the different effects in terms of information asymmetry. Both values are measured in a separate regression. Besides that, the data was adjusted to increase the robustness. By winsorizing the data, potential outliers in the 5th and 95th percentile that can influence the results are replaced. To further increase the robustness of the results, some additional analyses are included. In 7.3.1 the robust standard error regression is included and further on in 7.3.2, a subsample is used in which the observations with 0 values are removed from the sample. In the last section 7.3.3, an extra univariate analysis is carried out to investigate whether there is a difference between the initial return of the top and bottom group based on the independent variables.

7.4.1 Robust standard error regression

With robust multivariate regression, robust standard errors are used. These standard errors deal with homoscedasticity and a lack of normality. The robust regression can be used to account for influences of outliers and leverage and other aspects that can influence a normal regression. Results can be found in table 9.

Results of Regression Analysis of the Initial Return

Variable	Model 1	Model 1 Robust	Model 2	Model 2 Robust
$Constant$	-3.127 (-1.140)	-3.127 (-1.086)	-4.790*** (-1.775)	-4.790** (-1.990)
$R\&DEXP_{i,t}$	-0.306 (-0.546)	-0.306 (-0.485)		
$R\&DCAP_{i,t}$			0.112 (0.576)	0.112 (0.511)
$NrPat_i$	-0.011 (-0.038)	-0.011 (-0.036)	-0.162 (-0.572)	-0.162 (-0.543)
$Volume_{i,t}$	0.296 (1.309)	0.296 (1.276)	0.262 (1.146)	0.262 (1.080)
$Size_{i,t}$	0.148 (0.441)	0.148 (0.407)	0.216 (0.637)	0.216 (0.600)
$Leverage_{i,t}$	1.331 (0.706)	1.331 (0.715)	1,981 (1.055)	1,981 (1.079)
$Age_{i,t}$	-0.788 (-1.528)	-0.788 (-1.368)	-0.609 (-1.194)	-0.609 (-1.010)
R-Square	0.068	0.068	0.048	0.048
Adjusted R-Square	0.16	0.16	-0.005	-0.005
Number of Observations	115	115	115	115

* p<0.01, **p<0.05, ***p<0.1

Table 9: Robust regression results

This test does not check for heteroskedasticity itself. The Brush-Pagan and the White's test are used to test for heteroskedasticity. Both tests show an insignificant result which means that there is no linear or functional relationship between the predictors and variances of residuals. The point estimates of the variable coefficients stay the same as with the normal multiple regression, but the standard errors changed. The conclusions of the results from the multivariate regression in section 7.3 and this robust error regression are the same. No previously insignificant values from the normal multivariate regression became significant in this robust error regression.

7.4.2 Reduced sample analysis

In the dataset from this research, as in previous research, the value zero was used for the R&D values where no value was indicated in the database. By including these observations that did not invest in R&D the R&D data was skewed. In this additional analysis we only look at the observations that invest in R&D. In this way can be investigated how the level of R&D investment influences the IPO underpricing in only R&D intensive firms.

Descriptive statistics

The sample with observations containing expensed R&D values consists of 68 observations and the sample with observations with capitalized R&D values has a size of 42 observations. The descriptive statistics of the dependent and independent variables of these samples are shown in table 10a and 10b.

Descriptive statistics

Variables	N	Mean	Median	Std. Deviation	Minimum	Maximum
Independent variable						
$IR_{i,t}$	68	-1.325%	-1.387%	4.005	-5.977%	9.045%
Dependent variables						
$R\&DEXP_{i,t}$	68	117.547	74.284	107.835	0.046	309.375
$NrPat_i$	68	18.50	9.00	25.109	0	111

Table 10a: Descriptive statistics Expensed R&D observations

Descriptive statistics

Variables	N	Mean	Median	Std. Deviation	Minimum	Maximum
Independent variable						
$IR_{i,t}$	42	-0.569%	-1.481%	4.327	-5.977%	9.045%
Dependent variables						
$R\&DCAP_{i,t}$	42	91.184	47.278	99.717	0.002	391.018
$NrPat_i$	42	14.92	5.00	23.540	0	111

Table 10b: Descriptive statistics capitalized R&D observations

In table 10a can be seen that the mean initial return is -1.325% which is very similar to the median from this sample (-1.387%). On average over this sample, observations are overpriced and because of the negative median there are also more observations dealing with overpricing than underpricing. In table 10b the initial return is also negative whit -0.569% which indicates overpricing in general. However, this level is lower in comparison with the expensed R&D sample and the total sample. The median, on the other hand, is negative at -1.481%, which would mean that there are a number of values in this sample that explain the relatively low negative mean with this median.

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The average value of the expensed values is 117.547 and the average value of the capitalized R&D values is 91.184. In both samples the median appears to be lower than the mean which means that there are more R&D values in the sample that are lower than the mean. The mean values are of course higher than in the full samples because in these samples the observations were taken out with 0.

The average number of patents of companies in de expensed R&D sample is 18.50 which is higher than the average in the capitalized R&D sample (14.92).

Correlations

To have a look at the relationships between all variables, the correlation tables are analyzed (table 11a and 11b).

Correlations

	$IR_{i,t}$	$R\&DEXP_{i,t}$	$NrPat_i$	$Volume_{i,t}$	$Size_{i,t}$	$Leverage_{i,t}$	$Age_{i,t}$
$IR_{i,t}$	1						
$R\&DEXP_{i,t}$	0.045	1					
$NrPat_i$	0.227	0.083	1				
$Volume_{i,t}$	0.295**	-0.128	0,330*	1			
$Size_{i,t}$	0.243**	-0,408*	0.168	0,595*	1		
$Leverage_{i,t}$	0.037	-0.188	-0.029	-0.109	0.066	1	
$Age_{i,t}$	-0.118	-0.513*	-0.167	0.104	0.308**	0.118	1

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.01 level (2-tailed).

Table 11a: Correlation table expensed R&D observations

Correlations

	$IR_{i,t}$	$R\&DCAP_{i,t}$	$NrPat_i$	$Volume_{i,t}$	$Size_{i,t}$	$Leverage_{i,t}$	$Age_{i,t}$
$IR_{i,t}$	1.000						
$R\&DCAP_{i,t}$	0.069	1					
$NrPat_i$	-0.184	-0.020	1				
$Volume_{i,t}$	0.009	-0.292	0.092	1			
$Size_{i,t}$	0.025	-0.393**	0.081	0.0682*	1		
$Leverage_{i,t}$	0.005	-0.319**	0.276	-0.017	0.031	1	
$Age_{i,t}$	-0.062	-0.327**	-0.129	0.310**	0.385**	0.125	1

**. Correlation is significant at the 0.05 level (2-tailed).
*. Correlation is significant at the 0.01 level (2-tailed).

Table 11b: Correlation table capitalized R&D observations

As in the total sample, no significant result can be detected between the dependent and independent variables. This is therefore not in line with expectations. Compared to the full sample, a change can be seen in the relationship between the initial return and the R&D variables. Both R&D have a small positive relationship with the initial return. This suggests that investment in R&D increases the initial return, which could mean underpricing. In the two separate samples, there is a different relationship between the initial return and the number of patents. In the capitalized R&D sample this is negative, as it was in the total sample, but in the expensed R&D sample a positive relationship can be seen. The correlation between the R&D values and the number of patents within a company also differs between the two different R&D values. This is a remarkable difference.

Table 11a shows a significant result between initial return with both volume and size. This would imply that overpricing occurs more often with larger IPO volumes and larger companies. This is still not in line with expectations and results of previous studies, but it is significant in Table 11a.

As far as the control variables themselves are concerned, there is a similar pattern as in the full sample. For example, the significant relationship between volume and size is still present, but it is much lower in the case of capitalized R&D values. However, the significant relationship between volume and age falls away with the sample of expensed R&D values.

Regression analysis

Table 12 shows the regression results of the reduced samples. The regression for model 1 is done for the sample with only expensed R&D value observations and model 2 is done for the capitalized R&D value observations.

Results of Regression Analysis of the Initial Return

Variable	Model 1	Model 1 (Reduced sample)	Model 2	Model 2 (Reduced sample)
$Constant$	-3.127	-11.142	-4.790***	-3.427
	(-1.140)	(-2.103)	(-1.775)	(-0.511)
$R\&DEXP_{i,t}$	-0.306	0.202		
	(-0.546)	(0.512)		
$R\&DCAP_{i,t}$			0.112	0.341
			(0.576)	(0.026)
$NrPat_i$	-0.011	0.321	-0.162	-0.752
	(-0.038)	(0.832)	(-0.572)	(-1.377)
$Volume_{i,t}$	0.296	0.338	0.262	0.050
	(1.309)	(1.161)	(1.146)	(0.117)
$Size_{i,t}$	0.148	0.538	0.216	0.301
	(0.441)	(1.148)	(0.637)	(0.487)
$Leverage_{i,t}$	1.331	1.468	1,981	2.806
	(0.706)	(0.647)	(1.055)	(0.661)
$Age_{i,t}$	-0.788	-0.710	-0.609	-0.569
	(-1.528)	(-1.047)	(-1.194)	(-0.662)
R-Square	0.068	0.148	0.048	0.064
Adjusted R-Square	0.16	0.064	-0.005	-0.097
Number of Observations	115	68	115	42

* p<0.01, **p<0.05, ***p<0.1

Table 12: Robust regression results

The R-squared value of model 1 in the reduced sample is increased to 0.148 which means that the model describes 14.8% of the variation in the initial return. The model is just not statistically significant (P-value of 0.123) and therefore it cannot be concluded that the coefficient is not equal to zero. The R-squared value of model 2 in the reduced sample is 0.064 and therefore also increased. The P-value is 0.875 which shows that this model is very insignificant. Below the beta coefficient values the t-values are given.

The regression models of the reduced samples do not contain any significant relationships just as with the whole sample. Based on these results, it can again be said that the degree of innovation within a company does not influence the underpricing of an IPO. The individual results in the table are discussed in more detail below.

The difference between the influence of the expensed R&D ratio on the initial return between model 1 of the normal multiple regression and in model 1 of the reduced sample is striking. The direction of the influence has changed. In a sample where all observations have an expensed R&D value, the higher this value, the higher the initial return and thus the measures of underpricing. This result is in line with hypothesis 1.1. Between these two samples there is another change of direction. Namely in the case of the patent variable. The reduced sample of model 1 shows a positive value of 0.321, which means that the initial return is higher with a higher number of patents. This is not according to hypothesis 1.2.

7.4.3 independent sample T-tests with transformed R&D ratio's

Using a T-test, we can check whether there are significant differences between groups. These groups are created in this section based on the mean values of the independent variable. In this way it is possible to examine whether the top group in terms of expensed R&D values, capitalized R&D values and the top group in terms of the number of patents contain a significantly higher initial return than the lower-than-average group of these variables do. In this way, it is possible to indirectly explain a relationship between certain variables.

The results of the independent sample t-test are shown in table 13. In all three panels, no significant results can be found. Therefore, for all three independent innovation variables it cannot be concluded that there is a significant difference in means of the below average and above average group.

Univatiate analysis of innovation variables with initial return (without outliers)

Panel A: Results independent sample t-test Expensed R&D/Assets with Initial return						
		N	Mean	Difference	t-value	P-value
Initial Return	Above average	56	-1.27%	1.1313177	-1,497	0.137
	Below average	59	-0.14%			
Panel B: Results independent sample t-test Capitalized R&D/Assets with Initial return						
		N	Mean	Difference	t-value	P-value
Initial Return	Above average	40	-0.65%	0.0528399%	0.066	0.948
	Below average	75	-0.71%			
Panel C: Results independent sample t-test number of patents - Ln with Initial return						
		N	Mean	Difference	t-value	P-value
Initial Return	Above average	56	-0.78%	0.1774103%	-0.233	0.817
	Below average	59	-0.60%			

Table 13: Independent sample T-test

Panel A shows the t-test of the Expensed R&D ratio with the initial return. The above average group contains 56 observations where the below average group contains 59 observations. The result of the above average group shows a negative initial return (-1.27%) as mean and the below average group shows a small negative return (-0.14%). This shows that a higher expensed R&D value connects to a slightly lower initial return and therefore lower level of underpricing. The P value shows no significance but with a value of 0.137 it is not far from significant.

Panel B shows the t-test of the Capitalized R&D ratio with the initial return. The above average group contains 40 observations where the below average group contains 75 observations. The results of the means from the below average (-0.71%) and the above average (-0.65%) of the sample show almost the same value. Panel C shows the results of the independent sample t-test of the number of patents variable with the initial return. The difference in means (0.1774103 percentage point) is small.

7.4.4 Independent sample T-tests with reduced sample

Univatiate analysis of innovation variables with initial return

Panel A: Results independent sample t-test Expensed R&D/Assets with Initial return						
		N	Mean	Difference	t-value	P-value
Initial Return	Above average	38	-1.27%	0.1183372	0.120	0.905
	Below average	30	-1.39%			
Panel B: Results independent sample t-test Capitalized R&D/Assets with Initial return						
		N	Mean	Difference	t-value	P-value
Initial Return	Above average	22	0.40%	2.0327938	1.546	0.130
	Below average	20	-1.64%			

Table 14 shows the results of the independent T-tests without the natural logarithm transformation.

Table 14: Independent sample T-test with sample reductions

Panel A shows the t-test of the expensed R&D ratio with the initial return. The above average group contains 38 observations where the below average group contains 30 observations. The mean values of the two groups are very close to each other whit -1.27% (above group) and -1.39% (below group) so no real difference can be seen.

Panel B shows the t-test of the capitalized R&D ratio with the initial return. The above average group contains 22 observations where the below average group contains 20 observations. The results of the means from the below average (-1.645%) and the above average (0.40%) of the sample show that the above average group connects to a higher initial return and thus higher level of underpricing.

7.5 Discussion of the results

Earlier in this chapter, the results of this research are presented. The analyses did not reveal any significant relationship between the independent variable underpricing and the innovation variables used in this study. It may be that the previously mentioned "disadvantages" of the parameters had a greater impact than thought. These disadvantages were:

- The difference between research and development involves uncertainties (Bogle, 2017).
- Not all innovations always patentable and patent information varies in quality which affects information asymmetry (in agreement with(Chen & Shao, 2018)).

This section takes a closer look at possible (external) causes of these results by looking at recent changes in the IPO stock market, changes in the ways that companies organize an IPO, changes in characteristics of IPO companies and the influence of modern investment goals.

7.5.1 Changes in IPO stock markets

Over the past 10 years, investments have become more and more popular. In terms of the AEX prices, 2009 was the lowest point of the financial crisis, which started in 2008. There was also great uncertainty surrounding stock exchanges in 2011, the start of the dataset in this report. Since then, we have seen a rise in share prices. Confidence has returned and the ECB's interest rate policy has reinforced this rise in recent years. Interest rates are very low, which means that investors have fewer investment options and, therefore, more money goes into equity investments, which causes the prices to rise more. Rising prices then attract more investors, causing prices to rise even further. It can be said that the interest in IPOs is increased over the last 10 years. The value of IPOs also has increased compared to 10 years ago (see appendix I for figures). Despite the Brexit, the number of IPOs has remained relatively stable according to analyses with European IPO figures (PwC, 2018). The figures in appendix I show that the trend of the number of IPOs in Europe and within Euronext are similar. In 2014 and 2015 an increase was seen and in the years 2016 to 2019 a somewhat lower but stable trend of the number of IPOs follows. In 2020 a large peak can be seen and especially in the Euronext growth market. This could indicate a hot market for smaller growth IPO companies. The large time period covered by this study may have influenced the results. Changes in the market in terms of popularity and confidence can arise from external factors such as a Brexit, a crisis or regulation by the ECB. The measures of popularity and confidence in the market can influence underwriter pricing as this is partly determined by taking into account the current situation in the market.

7.5.2 Changes in the ways companies organize an IPO

Private companies have much more options to go public nowadays than before. Next to the normal way of going public via an IPO, it is possible to enter the public market with a SPAC or with a direct listing process.

Direct listing process

Direct listing is the case when a company wants to go public and offers its shares to any investor without doing a public raise. The direct listing process is a little different from the normal IPO process because of among others the function of the underwriter. With a direct listing the company hires many fewer bankers and these banks are separate from the listing as underwriters. The company itself will go public with its own forecast. The management itself will try to attract investors, but when it enters the market, it has no control over the price or over who gets the shares as there may be after a book building process. Within Europe, direct listing is primarily a commercial decision (and not really a legal decision). However, it is not yet a widely used method in Europe to enter the market. This is because the direct listing company should meet specific requirements in order for it to be an appropriate way to go public. An example of a company that entered the market in this way is Spotify. Spotify had no immediate need to raise capital and already had a diverse shareholder base. In addition, Spotify is based on an easily understandable subscription business model and a well-known brand with strong reputation before going public. This way of going public probably did not affect the sample or the results of this study because it is not yet common and contains specific requirements for companies.

SPACs

A major change in recent years has been the rise in popularity of SPACs. Special purpose acquisition companies (SPACs) are companies that are set up solely to acquire a business. A SPAC is often formed by an investor with expertise in a target industry or sector. SPACs enter the market as an IPO and the money raised from the IPO ends up in an interest-bearing trust account. This money can only be used for an acquisition or to return the money to the investors if the acquisition does not go ahead. The SPAC process is the point at which the target company becomes a public listed entity through the acquisition. SPACs have been around for a long time, but in recent years there has been a surge in popularity. This applies to a very large extent to SPACs in the US, but in Europe, too, they are becoming increasingly common and increasing growth is expected (Deloitte, 2021) (see Appendix I). However, current regulations do not yet allow investors everywhere to get their money back if they do not agree with the target, which means that SPACs are not yet popular throughout whole Europe. Especially in the Netherlands, the volume of SPACs is large compared to the rest of Europe (see Appendix I).

For target companies, an acquisition by a SPAC also means a number of advantages. Usually, the acquisition amount is higher than in normal equity deals, it is a cheaper way to enter the market and there is greater certainty around pricing than in a normal IPO. Underpricing will therefore appear less frequently. Investors and market conditions do not play a major role, but the SPAC and the target company together determine the value of the company and the price. This ensures that companies can get higher valuations from the market. Underpricing is no longer an issue in this case. When interesting innovative companies with a lot of growth enter the market via a SPAC, they fall outside the scope of this study. This can mean that in recent years when the SPAC has been increasingly popular, a number of innovative tech companies are not included in the sample due to this other type of IPO. This topic can be an interesting research direction for follow-up research.

7.5.3 Changes in characteristics of IPO companies

In the past, it usually were the large multinationals that went to the stock exchange. These companies can still be seen on the stock exchange, but within the innovative technology companies, they are often smaller and younger companies. Among other things, the new methods of entering the public market mean that there are more options for entering the market much earlier in their life cycle. Technology companies today are often platform companies that can scale quickly and thus easily deploy internationally. Earlier research by Janssen (2019) already proved that significantly more underpricing takes place in the IPOs of start-up companies than in normal comparable industry IPOs. This may explain the finding in this study that there is a positive relationship between the initial return and the size variable (showed significance in the R&D sample).

It is also notable that in recent years there have also been regular IPOs of highly innovative companies that did not yet make a profit during the IPO. This has a higher risk and can perhaps lead to larger outliers on the first day of the IPO compared to companies with a stable and predictable profit development. However, this is not something that is reflected in the data. The average level of difference in pricing is not very high in comparison with mentioned values in other research. This may be because Euronext Growth's IPOs are not included in this dataset. Euronext Growth consists mainly of small, high-technology companies that often produce higher swings such as Janssen confirmed.

7.5.4 Modern investment goals

In this study, innovation is measured by R&D investments and patents. However, despite the frequent use and endorsement in the literature of these parameters, they may be outdated and no longer fully consistent with the current focus of investors on innovation. Very relevant at the moment, for example, is the degree of sustainability of a company. The green agenda has become a guiding principle through decision-making at EU and national level (Sandbu, 2021). Since 2010 there has been a clear growth in the number of assets involved in sustainable investing (Pwc, 2011). A growing number of investors are investing based on Environmental, Social and Governance (ESG) criteria and this has also become essential in recent years (Morgan Stanley, 2020).

Sustainability can be an important trigger for investors to invest in a company or not. Sustainability concerns issues such as climate, CO2 emissions and circularity. For large investors such as pension funds and insurers, there is also a pressure from the customer on the green content of the investment portfolio in terms of sustainability. This may concern companies that contribute to a sustainable society, but also the extent to which a company adapts to the new conscious society. Not implementing sustainability can cause a loss of competitive position. According to PWC's research, companies that capitalize on opportunities and mitigate risks in the area of sustainability make a stronger start of a successful public offering. Research on this topic in the US proved that the frequency of the presence of ESG terms in the IPO prospectus significantly explained IPO underpricing (Mai Anh & Frongillo, 2020).

This increasing focus on sustainability does not fully explain why no significant relationship can be found between R&D and the number of patents in this study. Innovation is still an important item, especially if we look at the interest in shares of the technology sector, but in the broad sense of innovation, the transition of recent years can mean that a factor of sustainability is missing from the analysis.

8 Conclusion and recommendations

This chapter concludes this thesis. 8.1 will present a summary conclusion and 8.2 describes the limitations and recommendations for further research.

8.1 Conclusion and summary

This research investigated the influence of innovation on the underpricing of initial public offers for a European sample from 2011 till 2021. The information about innovation can differ, which could have a great influence on the measures of underpricing. Therefore, the information asymmetry theory is interesting. In line with other research the information asymmetry theory has been taken into account as an explanation for underpricing of an IPO. All underpricing theories based on information asymmetry assume that underpricing is positively related to asymmetric information (Ritter & Welch, 2002). Therefore, according to this theory, the lower the information asymmetry the less underpricing is expected. Innovation as a variable has been split into input and output and a distinction has been made in the way of reporting the innovation input variable. This is because it was expected that different influences would follow from these variables. For hypothesis development, previous related research, information asymmetry theory and possible institutional influences were used.

Based on previous research and information asymmetry theories, the hypothesis in this research is that also in the European sample, as used in this study, a relationship would be found between innovation within a company and the degree of underpricing of this company at the IPO. It was hypothesized that a higher degree of expensed R&D would increase the degree of underpricing, while a higher degree of capitalized R&D and a higher number of patents would decrease the degree of underpricing. A markable difference with previous studies (Ritter & Welch, 2002) (Zhou & Sadeghi, 2019) (Heeley, Matusik, & Neelam, 2009), the most company observations show overpricing and no underpricing. This can be a feature of the Euronext stock exchange, but also of the European IPO market.

Based on the statistical analysis in this study, no influence between innovation and underpricing can be determined because no significant results follow from the regression analysis. The following conclusions about the study are based on the insignificant results of the analyses.

From the regression analyses and the additional analyses, a varying relationship between the expensed R&D variable and the initial return emerges. In the full sample where companies that do not make R&D investments are included, there seems to be a negative relationship in the correlation matrix, T-test and regression analysis. This implies that expensed R&D would lower the measures of underpricing. However, within the sample with only observations that receive expensed R&D, there appears to be a positive relationship between the expensed R&D variable and underpricing. This would mean that investing in R&D gives a positive and certain signal and lowers the degree of underpricing, but assuming that an R&D investment has been made, the higher the investment, the more uncertainty arises and thus the higher the measures of underpricing. The latter is in line with hypothesis 1.1.

In the analyses, the capitalized R&D variable has a non-significant but positive relationship with the initial return. The level of capitalized R&D variable increases the level of underpricing according to the results of the different analyses. This is not in line with hypothesis 1.2 in which a negative relationship was expected because the capitalized R&D value gives information about the valuable investments made in innovation based on the information asymmetry theory. An explanation may be in line with that of Bogle (2017) that it can be difficult for a company to make the split between expensing and capitalization, and it is complicated to determine when criteria for capitalization are met. As a result, capitalized value may appear less reliable to investors.

Regarding the number of patents, there seems to be a small negative relationship with level of underpricing in the total sample for both models. However, in the separate R&D samples the relationship differs in model 1. More frequently, a negative relationship seems to emerge from the analysis, which is in line with hypothesis 2. The insignificance and the change could be explained by the fact that no difference in transparency of patent values was added within the study.

In conclusion, this thesis does not show a significant impact of innovation on IPO (under)pricing in Euronext stock exchange IPOs. The insignificant findings are not fully in line with the information asymmetry theory-based hypotheses. Reasons for the levels of underpricing may have to do with other causes of underpricing (institutional statements, ownership and control, behavioral statements). Not finding a significant link between innovation and underpricing may have to do with various changes in the investment world that have taken place in recent years. Investing in equity is very popular and the focus on sustainability may have an effect on the results.

8.2 Limitations and recommendations

In section 7.5, several interesting views were introduced. In follow-up research, it may be interesting to consider the mentioned factors. Next to those some more practical recommendations will follow in this section. These recommendations follow from some limitations for this research.

A limitation in this study is the sample size of the research. Where other, referenced to, studies can base their results on about thousand observations this research is conducted with 115 observations. This is the case because all different variables are hand collected in combination with a limited time span for this research results in a small sample size. A larger sample size in a further for this research could possibly lead to significant results. With a larger sample size, a focus on all of Europe and not just the Euronext stock exchange would also be appropriate. On the one hand because this is necessary when you want to avoid the influences of changes in the market from a large period (section 7.5), but also because this can give a complete picture of the IPO market in Europe. Currently, a very large part of the sample comes from Euronext Paris.

Because of the data availability, Euronext Growth was not used. Euronext Growth consists mainly of small, high-tech companies that raise less capital. Due to the high level of innovation within high-tech companies, this is very interesting for a follow-up study. It also can be valuable to focus on a certain sector because the difference in innovation can also be related to the sector of the company. In this study the sample size was too small to add a separated analysis per sector.

Among the methodology, we can also classify several limitations. A number of control variables were used in the study, but other factors can also play a role. The choice of underwriter plays a major role. Size and reputation of the underwriter can influence underpricing. This also applies to the presence of a venture capitalist. Furthermore, the patent variable contains some limitations. Different data sources (Orbis and EPO) showed different values for the patent count. The source EPO sounds reliable, but no cross-check of the patent data could take place because this data was not available in other sources. Next to that the EPO data was obtained with help of a self-written algorithm and not via EPO rankings. Therefore, the reliability of the data is questionable. In further research it may be valuable to add not only a number of patents but also other patent variables such as the transparency and values of a specific patents.

What is surprising about the data is that, in general, there is little underpricing and more often overpricing. In retrospect, it would have been interesting to also look at the return of a week or month after the IPO, because then you can say something with much more certainty about the performance of the IPO on the market. The course of the market/stock exchange price can have a lot of influence on the extent of underpricing on the first day.

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Appendices

Appendix A – Number of IPOs over the years (EU, US, CN)

1. <u>European IPO Activity</u>
   Volume of European IPO markets

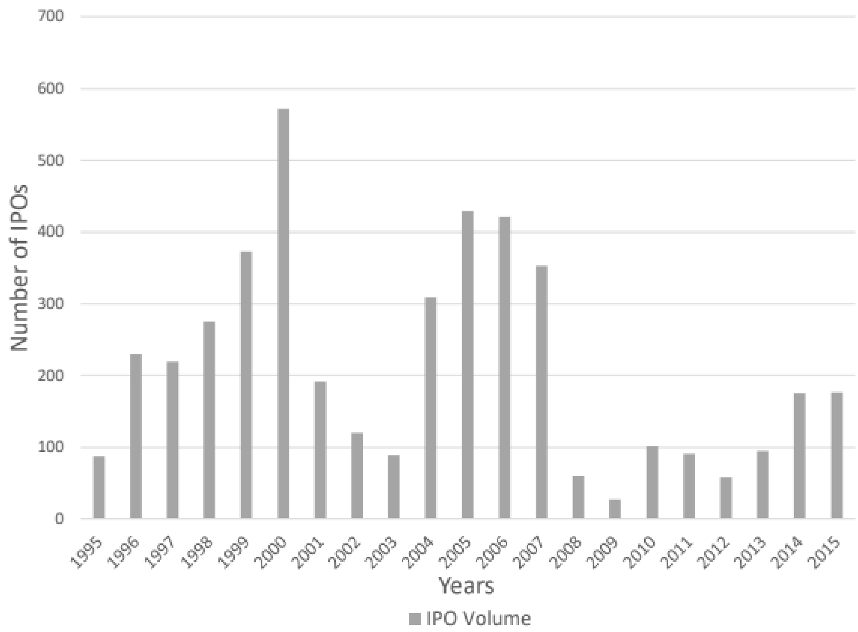


Figure 5: Volume of European IPO markets from 1995 till 2015 (Ritter, Signori, & Vismara, 2013)

2. <u>USA IPO Activity</u>
   Volume of the American IPO market

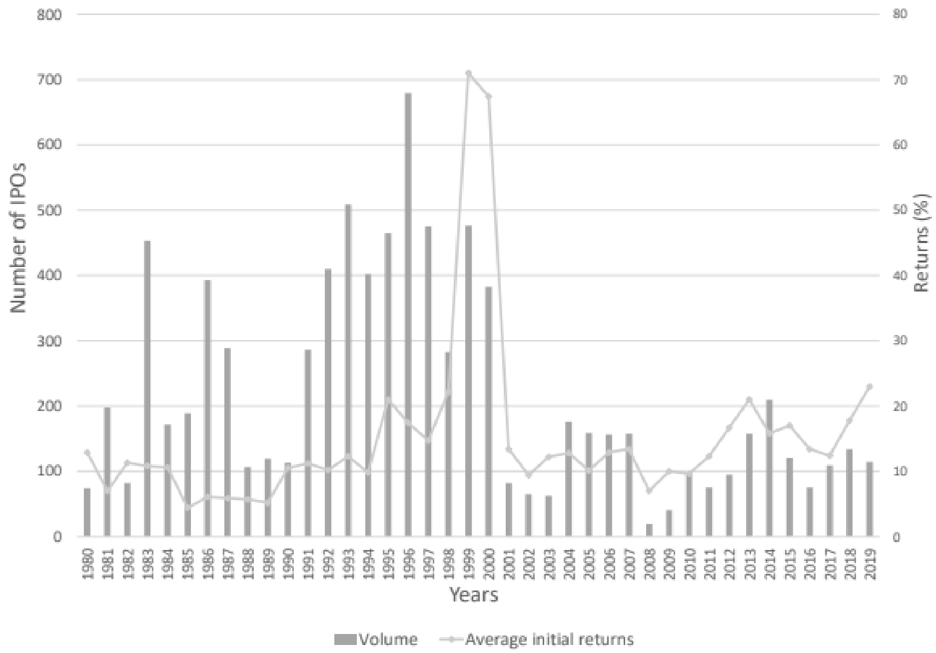


Figure 6: Number of US offerings and average percentage first day return (Ritter, 2020)

3. <u>China IPO Activity</u>
   Volume of China's IPO market

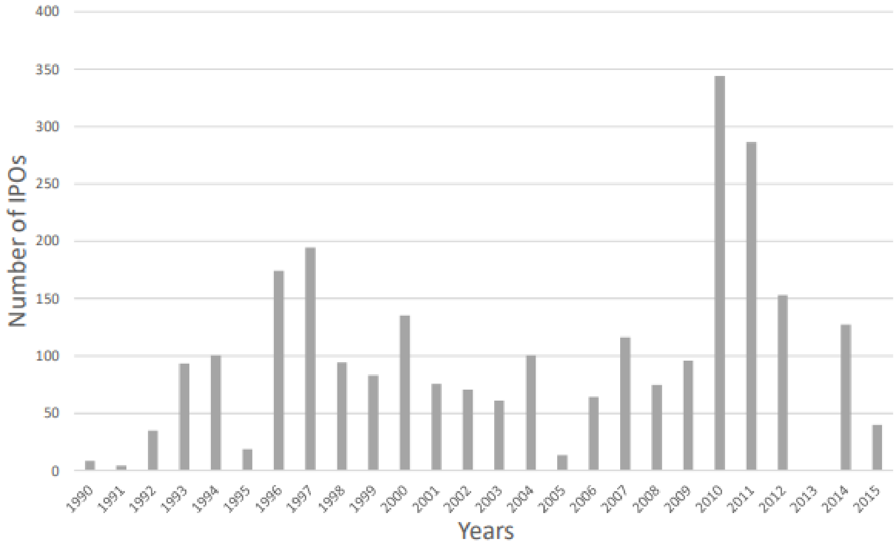


Figure 7: Activity of the IPO market in China between 1990 and 2015 (Azevedo, Guney, & Leng, 2018)

Appendix B –Stock valuations US

Valuations today are nowhere near what they were in the late 1990s.

Figure 8: Price-to-earnings (P/E) ratio of US Stocks (Maggiulli, 2020)

Appendix C – World IPO market differences

Appendix A shows the figures of the IPO activity in Europe, the US and China. Underpricing varies by time and sector, but it also varies greatly between countries (Loughran, Ritter, & Rydqvist, 1994). Averages within countries over several years show that underpricing in China is much higher than that in Europe and the US (Loughran, Ritter, & Rydqvist, 1994) (Tian, 2011)**.** The average underpricing between 1990 and 2018 in the US was 21.3%. In the various countries in Europe, in exceptions such as Sweden and Italy, the maximum is around 30 to 40%. On average, underpricing between 1995 and 2011 was around 16%, while in China it is 247% on average. According to Ritter & Welch (2002) the explanation for these excessive IPO returns lies in financial regulations and China-specific investment risks. Corporate governance in China is special because of the combination of minority shareholders and state shareholders.

A characteristic of the European stock market is that it is relatively small. The US IPO market is much larger and Europe is characterized by a more fragmented regulation (Ritter, Signori, & Vismara, 2013). The US IPO market is more regulated and much more protected (Kotecha, 2019). This makes going and being public a lot more expensive and complicated in the US. Also interesting is that the competition is also much greater in the US. In Europe, the 'stage' is somewhat less crowded, but IPOs there can benefit greatly from the large amount of attention they can receive. This is especially the case for small companies and exciting technology companies. It also appears that there is greater uncertainty for investors due to the lower level of regulation in Europe. This can make it more difficult to generate external funds. In Europe, therefore, 'new markets' have been set up where the stricter listing and disclosure requirements imposed on issuers. These new markets are: The Nouveau Marché in Paris, the Nieuwe Markt in Amsterdam, the Nuovo Mercato in Milan, Euro.NM Brussels and the Neuer Markt in Frankfurt. The official market must comply with the EU issuer disclosure regime. There are strict rules for entering this market in terms of disclosure and prospectus, but not in terms of size and minimum return. So, it is relatively easy for small companies to become listed companies.

Appendix D - IPO Stock market figures

1. Leading countries in the IPO market

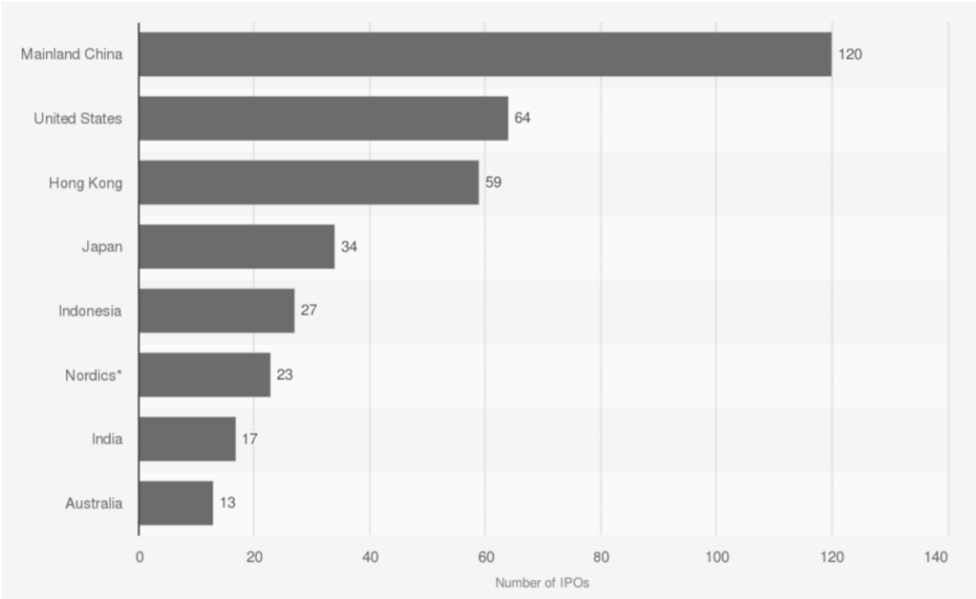


Figure 9: Leading countries by number of company IPOs in the first half of 2020 (EY, 2020)

2. *European IPOs*

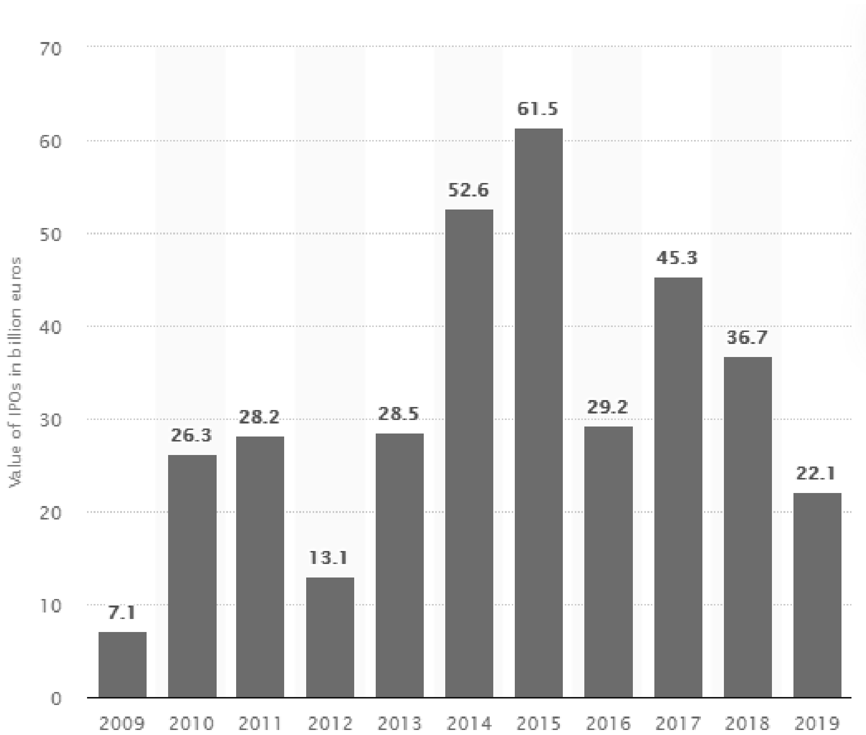


Figure 11: Total value of IPOs in Europe from 2009 to 2019

Appendix E – Origin of the legal system

The legal origin of a country tells a lot about the legal environment in a country and several studies confirmed that legal origin of systems causes fluctuations in underpricing (Sundarasen, Goel, & Zulaini, 2017) (Banerjee, Dai, & Shrestha, 2011). The legal origins theory states that the rules and regulations of the legal system are influenced by (English) common law countries or (French) civil law countries (La Porta, Lopez-de-Silanes, & Shleifer, 2008). The legal systems have been spread around the world mainly by colonization. Civil and common law systems have different historical origins and structurally operate in different ways (Glaeser & Shleifer, 2002).

Civil law courts often have professional judges, legal codes and written records. Next to that civil law courts use much stricter rules (La Porta, de Silanes, Shleifer, & Vishny, 2019). Civil law countries are more bank-based, the government is more clearly present in rules and ownership and this does not always have a positive impact on the market (La Porta, Lopez-de-Silanes, & Schleifer, 2007). There is often good protection for insiders, but less protection for outside investors. Besides French civil law, there is also German civil law and Scandinavian civil law. These two variants are more moderately oriented towards market institutions than French civil law and have slightly stricter protection of investor rights. Common law uses lay judges and broader legal principles. The judges are independent in executive and legislative terms. There is a lower degree of government intervention in common law countries and therefore the legal system is more market-based. The legal origin of a country has an influence on the legal rules that affect the financial structure. Therefore, financial development in common law countries is generally higher, stock markets are larger, dividend payouts and company valuations are higher (La Porta, de Silanes, Shleifer, & Vishny, 2019) (Caprio, Rigamonti, & Signori, 2020).

Figure 12 shows the distribution of legal origins around the world. The US is a common law country. This explains why the US stock market is bigger. Why there are many more active investors and why these face less risk compared to Europe. European countries, except for Ireland (and Cyprus), all belong to the civil law origin, but still differ from each other in terms of type.

Figure 12: The distribution of legal origin (La Porta, Lopez-de-Silanes, & Shleifer, 2008)

Sundarasen (2019) concludes in her research that signaling variables have a stronger impact on IPO initial returns in civil law countries This implies that the confidence that signaling gives through underpricing about the value of a firm is more important in civil law countries. There, the corruption level is very low, which reduces the effect of signaling. Also, the generally better investor protection rules in common law countries (and Scandinavian civil law countries compared to other civil law countries) may have an effect. On average, civil law countries are expected to have a higher level of underpricing than common law countries.

The list of countries divided in legal origin according to (Engelen & van Essen, 2010), (La Porta, de Silanes, Shleifer, & Vishny, 2019) (La Porta, Lopez-de-Silanes, & Shleifer, 2008) is shown below. some countries were difficult to classify under the different civil law types and therefore were not included.

Common law:

Ireland

United Kingdom

Cyprus

German Civil law:

Germany

Estonia

Czech Republic

Poland

Hungary

Slovakia

Slovenia

Romenia

Bulgaria

Croatia

Italy (German with elements of French civil law)

Scandinavian Civil Law:

Finland

Denmark

Sweden

Norway

French civil law:

Austria (Germanic)

Belgium

The Netherlands (German law influence)

Spain

Portugal

France

Italy (Germanic with elements of French civil law)

Luxembourg

Greece

Appendix F – Separation development from research

	Research	Development
Definition	Costs related to original and planned investigation undertaken with the prospect of gaining new scientific or technical knowledge and understanding.	Incurred in the application of research findings or other knowledge to a plan or design for the production of new or substantially improved materials, devices, products, processes, systems or services before the start of commercial production or use.
Examples	• Activities to obtain new knowledge on self-driving technology. • Search activities for alternatives for replacing metal components used in a company's current manufacturing process. • Search activities for a new operating system to be used in a smart phone to replace an existing operating system.	• Design and construction activities related to the development of a new self-driving prototype. • Design and construction of a new tool required for the manufacturing of a new product. • Testing activities on a new smart phone operating system that will replace the current operating system.

Figure 13: Definitions and examples of Research and Development according to (Bogle, 2017)

Appendix G – MySQL code EPO database

```
SELECT top 10000  psn_name,
COUNT(distinct(case when appln_filing_year = 2010 then tls201_appln.appln_id end)) as '2010',
COUNT(distinct(case when  appln_filing_year = 2011 then tls201_appln.appln_id end)) as '2011',
COUNT(distinct(case when  appln_filing_year = 2012 then tls201_appln.appln_id end)) as '2012',
COUNT(distinct(case when  appln_filing_year = 2013 then tls201_appln.appln_id end)) as '2013',
COUNT(distinct(case when  appln_filing_year = 2014 then tls201_appln.appln_id end)) as '2014',
COUNT(distinct(case when  appln_filing_year = 2015 then tls201_appln.appln_id end)) as '2015',
COUNT(distinct(case when  appln_filing_year = 2016 then tls201_appln.appln_id end)) as '2016',
COUNT(distinct(case when  appln_filing_year = 2017 then tls201_appln.appln_id end)) as '2017',
COUNT(distinct(case when  appln_filing_year = 2018 then tls201_appln.appln_id end)) as '2018',
COUNT(distinct(case when  appln_filing_year = 2019 then tls201_appln.appln_id end)) as '2019',
COUNT(distinct(case when  appln_filing_year = 2020 then tls201_appln.appln_id end)) as '2020',
COUNT(tls201_appln.appln_id) total
FROM   tls201_appln  join tls207_pers_appln on tls201_appln.appln_id =
tls207_pers_appln.appln_id
join tls206_person on tls207_pers_appln.person_id = tls206_person.person_id
join tls801_country on tls206_person.person_ctry_code = tls801_country.ctry_code
WHERE
appln_auth = 'EP'
AND appln_filing_year between 1900 and 2020
and applt_seq_nr > 0
and eu_member = 'Y'
group by psn_name
order by total desc
```

Appendix H – Data & assumption checks

Checking the data and assumptions for linear regression analysis before using the data in a regression analysis is important because it increases the reliability of the results. Without checking the data the coefficients can be misleading. After the assumption tests can be decided to adjust the data. Because the data is already winsorized no outliers will be deleted. The data of the regression analysis consists of on continuous dependent variable and two continuous independent variables. The observations are independent of each other. The following sections cover the main assumptions:

1. <u>Histogram inspections</u>

The histograms of de variables are produced to see if the distributions make sense. Histograms are made for all independent and control variables. The histograms are made after winsorizing the data on the 5th and 95th percentile.

R&D Ratio's

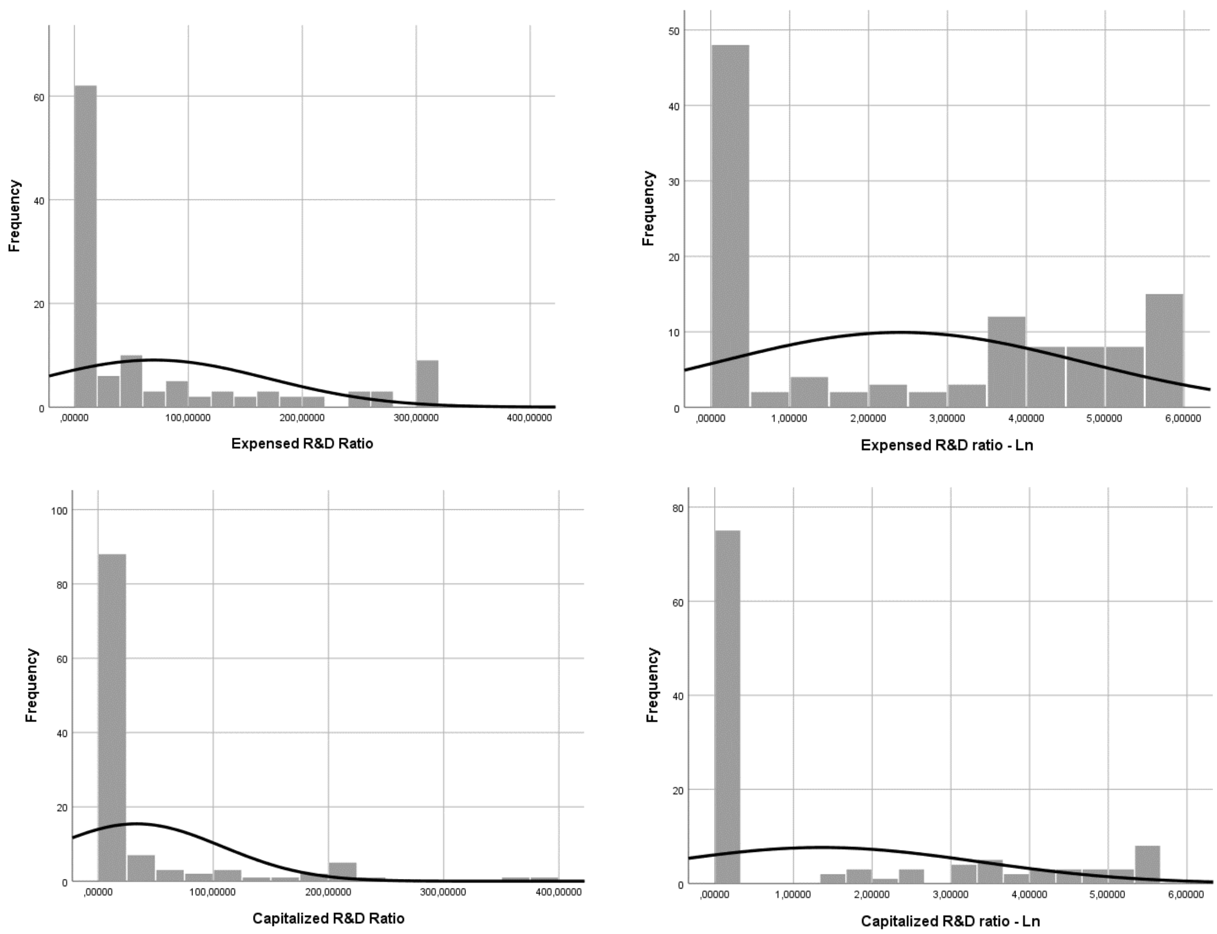


Figure 14: Histograms of R&D ratio variables

Number of patents

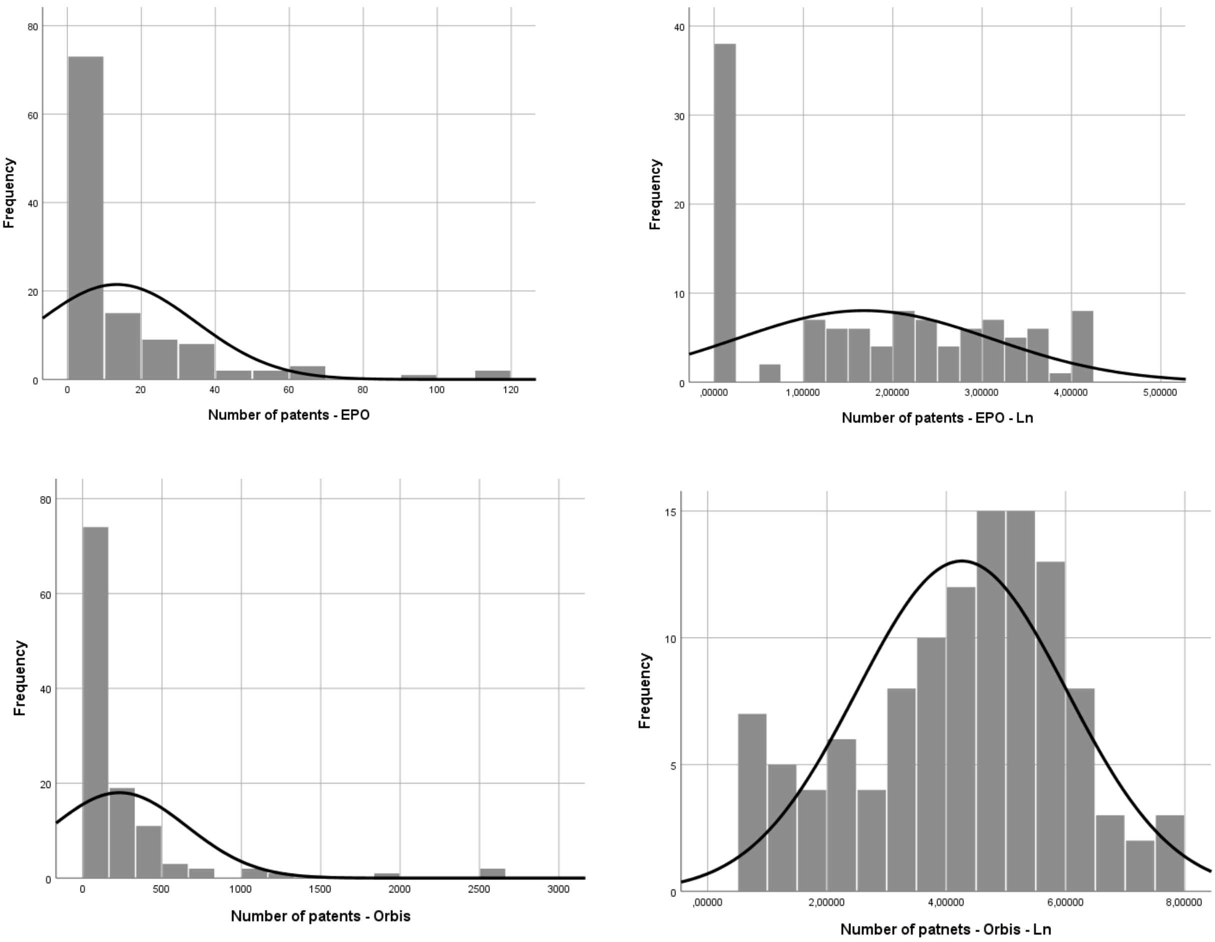


Figure 15: Histograms of the number of patent variables

Control variables

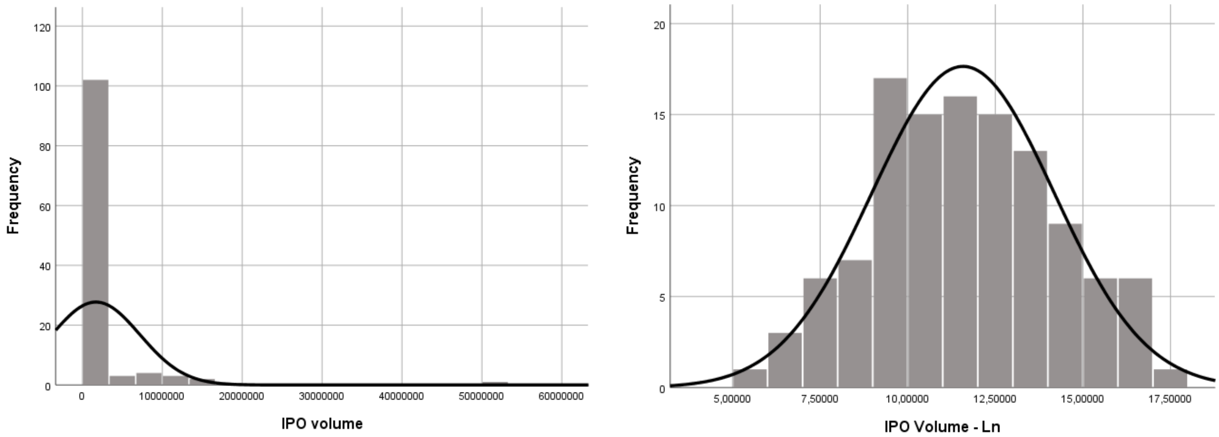


Figure 16: Histogram of the IPO volume variable

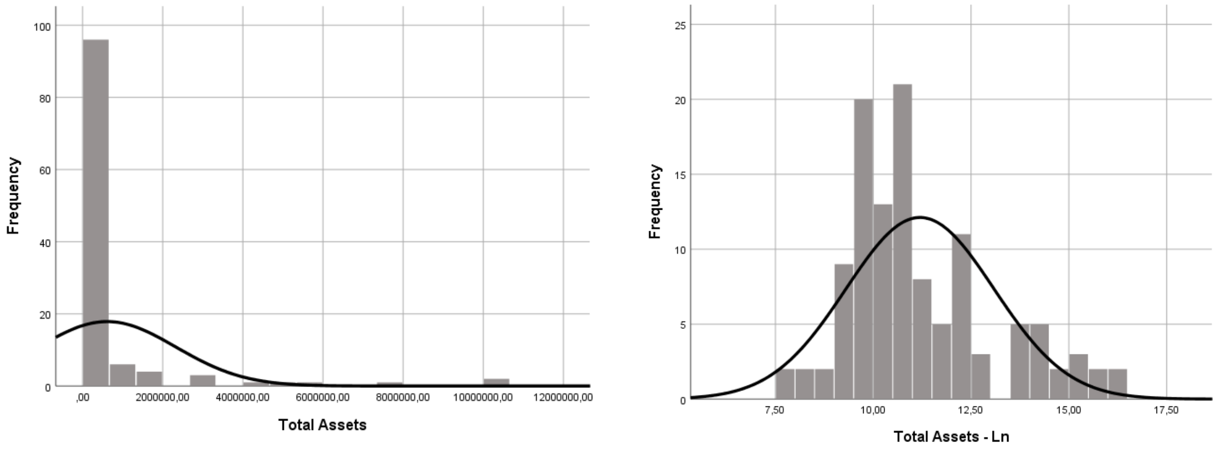


Figure 17: Histogram of the size variable

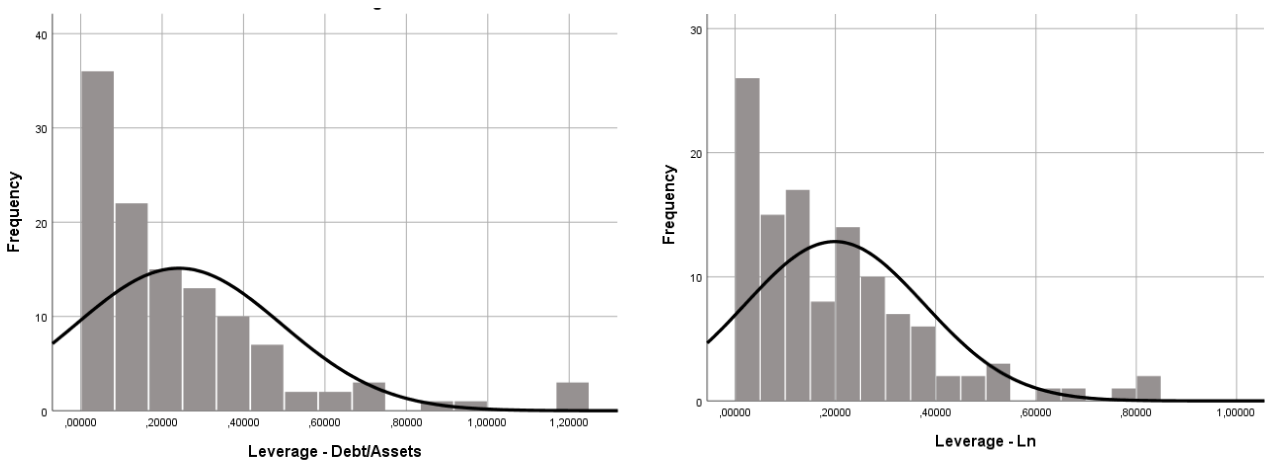


Figure 18: Histogram of the size variable

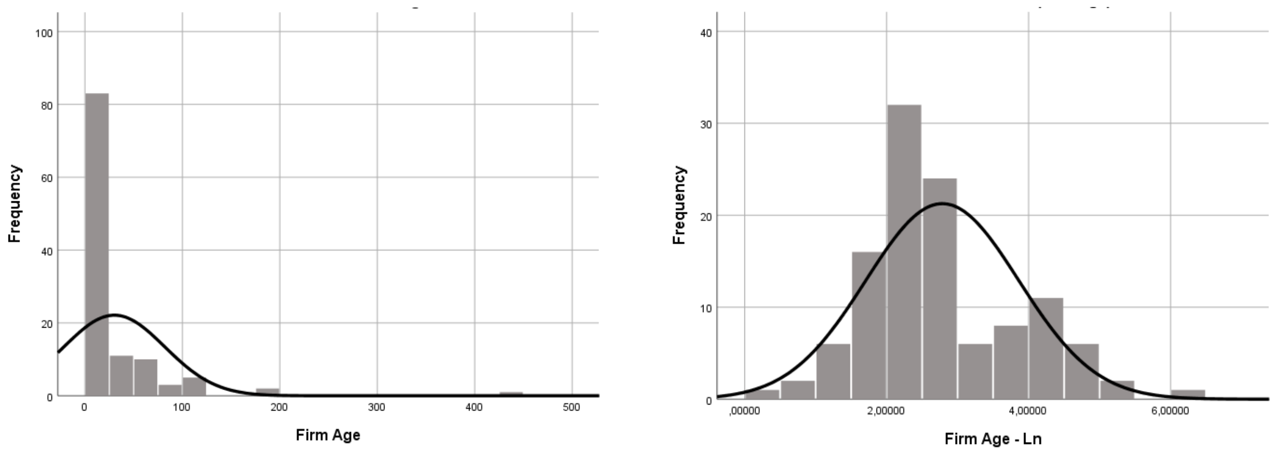


Figure 19: Histogram of the Firm Age variable

2. Testing assumptions

In this research is one dependent variable measured at the continuous level. There are two independent variables that are measured at the continuous scale as well. The following assumptions that are tested relate to the nature of the data. In the step of the linear relationship the linearity is questionable. Based on that results is decided to apply transformations. The R&D ratios have been transformed with the natural logarithm. No observations have been removed from the dataset because the data was winsorized. After that the assumptions are checked again for the new cases. These are presented in the following tables and figures.

Independence of observations

In SPSS the independence of observations is checked using the Durbin-Watson statistic. The Durbin-Watson test can detect possible autocorrelation. The Durbin-Watson statistic for this analysis is 1.980, which is close to 2. The statistic can range form 0-4 but a value of approximately 2 indicates that there is no correlation between residuals. It can be said that there is independence of errors in this dataset.

Linear relationship

The linear relationship between independent variables collectively and apart to the dependent variable can be tested in SPSS with a scatterplot a partial regression plots. The partial regression plots below of the R&D ratio's without transformation the initial return do show almost a point cloud. The linearity is questionable and therefore the R&D ratio variables are transformed with a natural logarithm.

Partial regression before transformation:

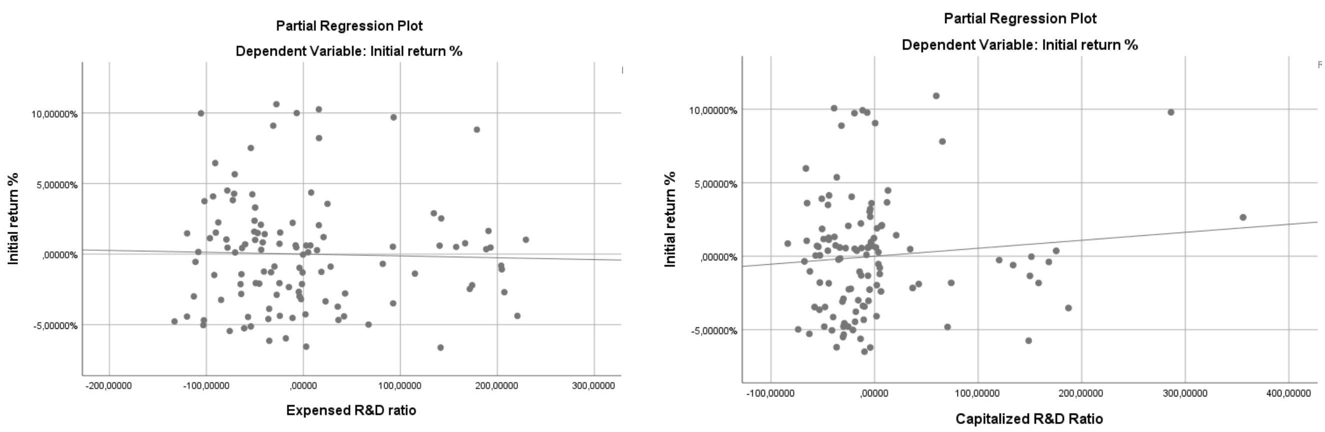
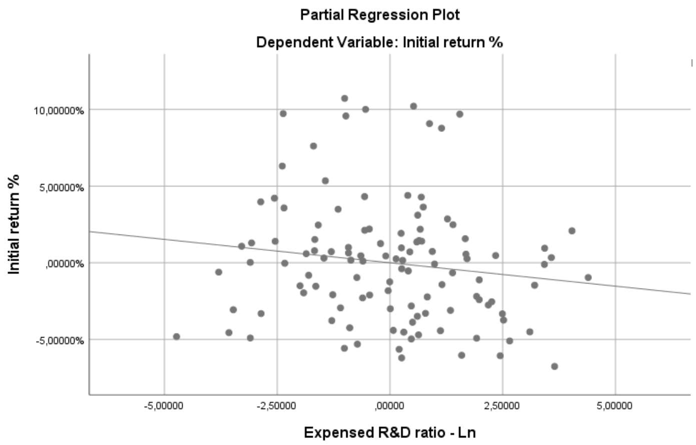
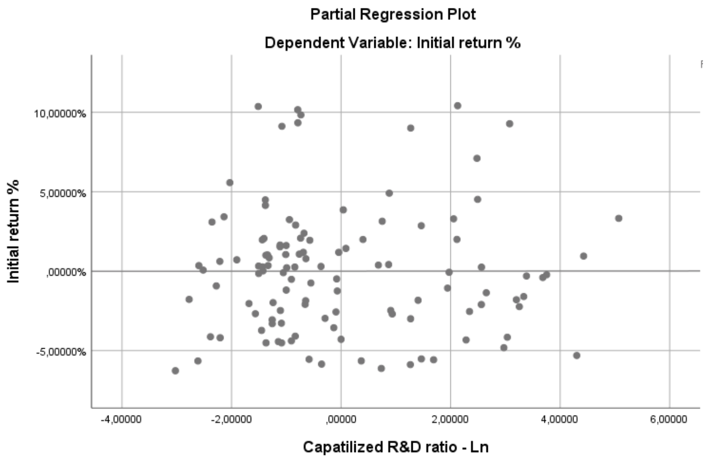


Figure 20: Partial regressions R&D ratio's

Partial regression after transformation:





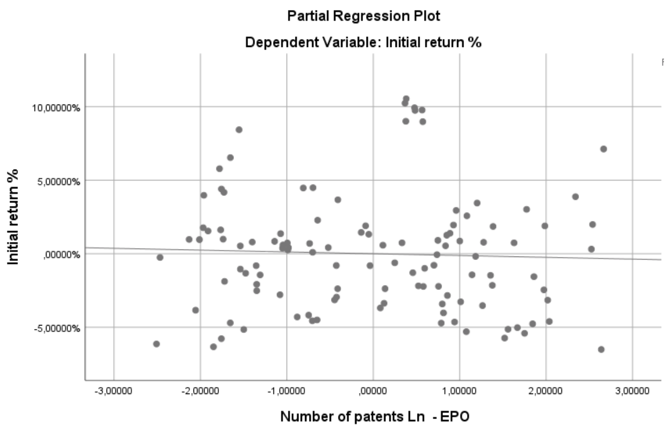


Figure 21: Regression plots independent variables

The linear relationship between independent variables collectively can be tested with the scatterplot of the studentized residuals against the predicted values shows a linear relationship (figure 22).

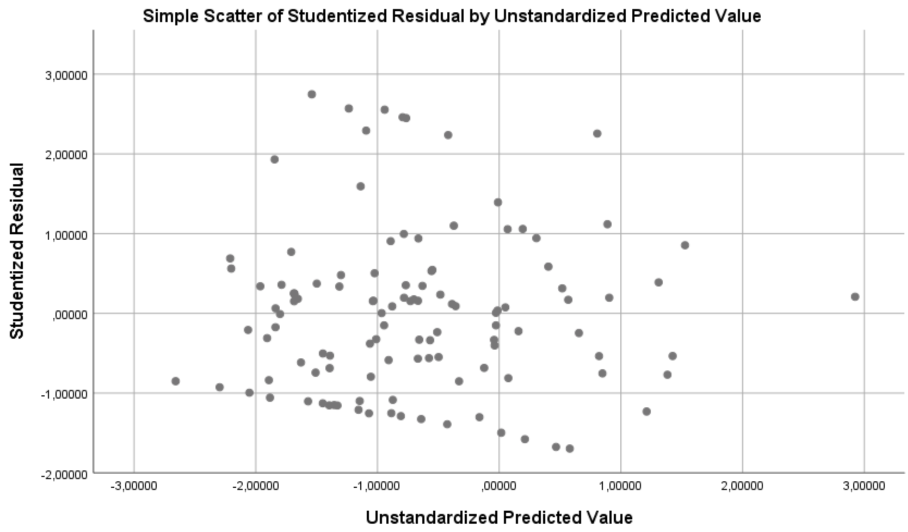


Figure 22: Scatter plot

Homoscedasticity of residuals

To test the equal error of variances (homoscedasticity) the plot of studentized residuals against the unstandardized predicted values is used again. In the scatter plot can be seen that the points are approximately constantly spread which would mean there is homoscedasticity.

No multicollinearity

The correlation table contains no correlations larger than 0.7. Next to that, The VIF does not show high values because there are no tolerance values smaller than 0.1 (VIF > 10). Therefore it can be expected that there is no problem with multicollinearity in this data set.

Checking for unusual points

There are different possible unusual points that can be found in data: outliers, high leverage points and highly influential points.

Outliers can be found by the case wise diagnostics table shows any observation where the standardized residual is greater dan 3 or smaller than -3. The value of -/+ 3 is a common cut-off point. No observations are shown as a big outliers and are removed.

Checking for leverage points can be done by the variable leverage value that can be saved during the linear regression in SPSS. Values above 0,5 are seen as dangerous. The saved variable in our dataset does not show any values above 0.3 so there are no high leverage points that have to be deleted. Checking for influential points can be done with using cook's distance values also in SPSS. Rule of thumb is that values above 1 should be investigated. The Cook's Distance value does not show any values above 0.6 so it can be assumed that there are no highly influential points in the data.

Checking for normality

The histogram and the P-P Plot show a approximately normal distribution. The mean in the histogram is approximately zero and the standard deviation is approximately 1. The points in the P-P Plot are not perfectly along the diagonal line but quite close.

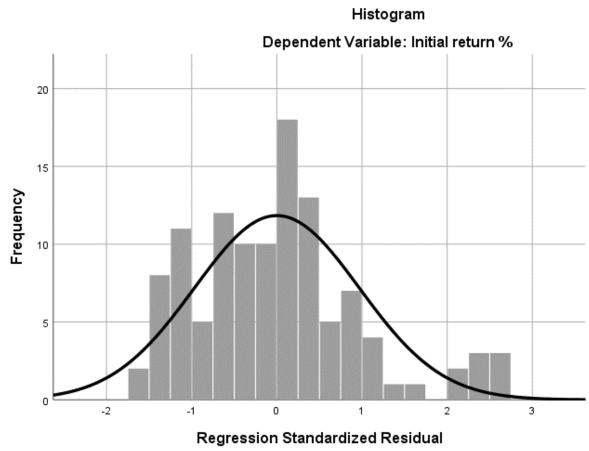


Figure 23: Histogram independent variable

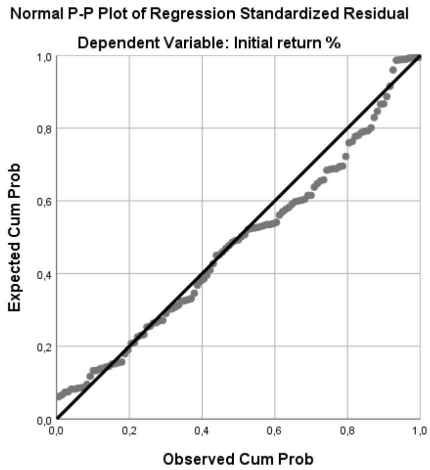


Figure 24: P-P plot

Appendix I – Discussion of result figures

The following figures show some background for the points mentioned in the discussion of the results as possible causes for insignificant results.

Index development

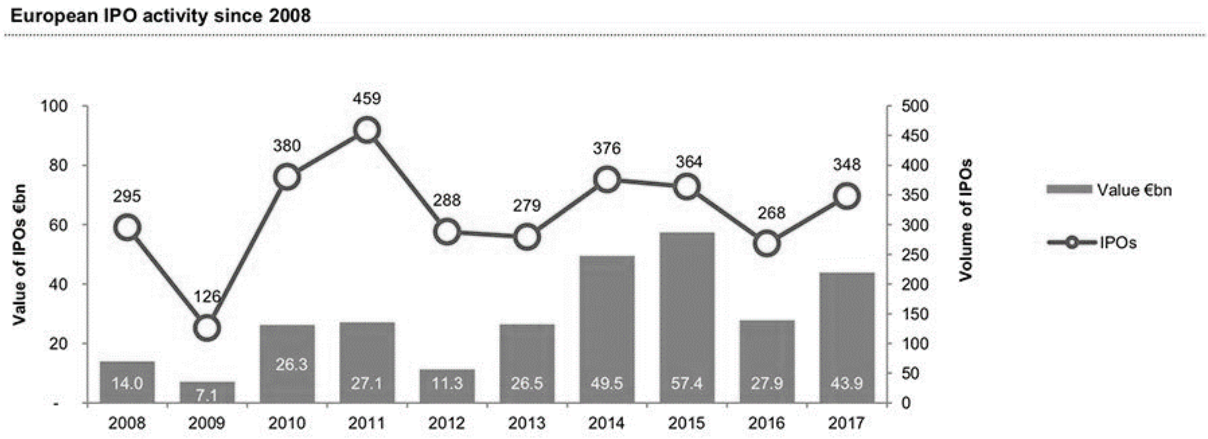


Figure 25: European IPO activity 2008-2017 (PwC, 2018)

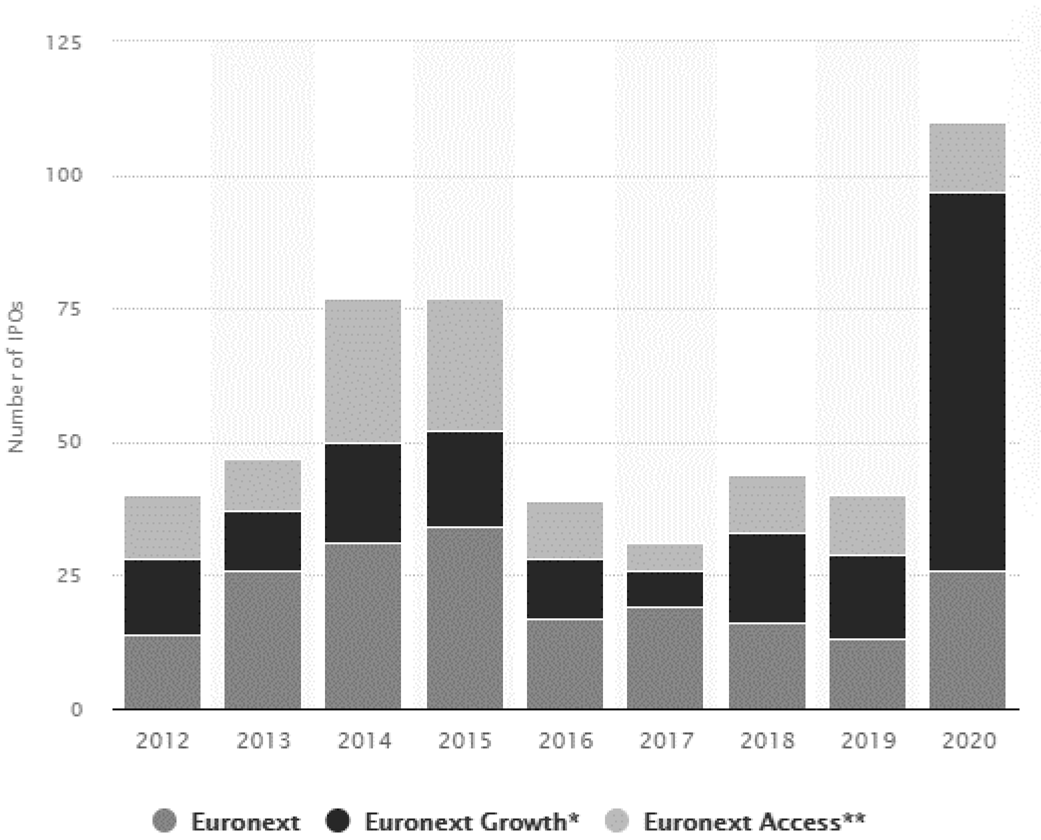


Figure 26: Number of IPOs 2012-2020 from statista based on NYSE Euronext

SPAC

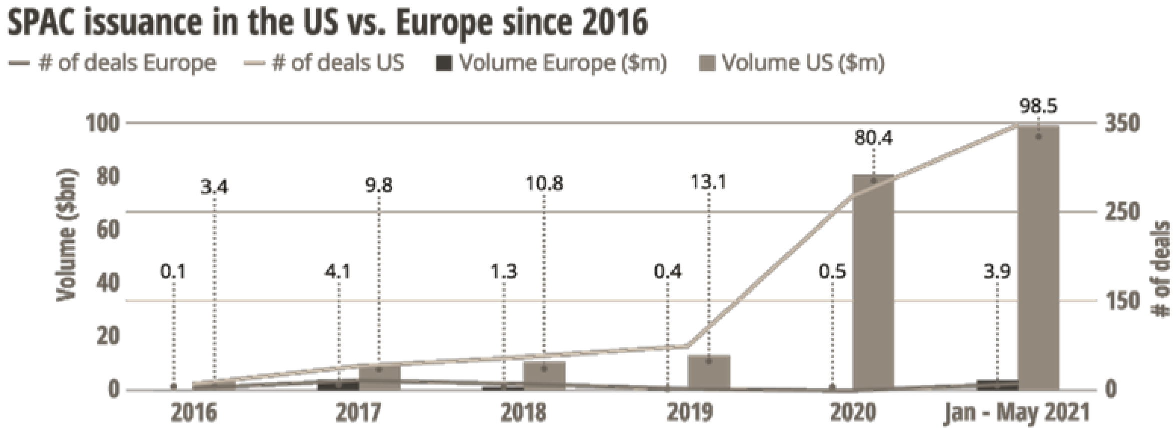


Figure 27: SPAC volume from 2016 till 2021 (Deloitte, 2021)

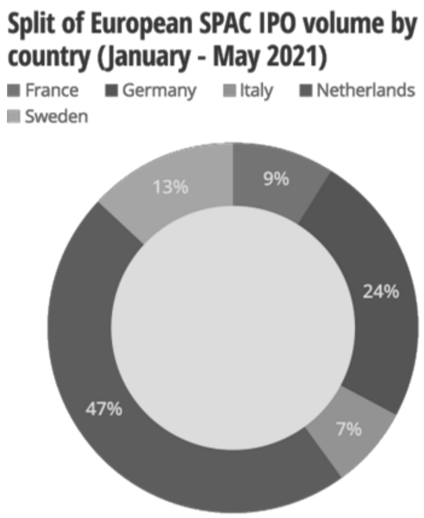


Figure 28: Split of European SPAC volume by country (Deloitte, 2021)