# The stock market and innovation –
## Does the stock market attract, select and boost innovation?

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**Abstract**
This paper explores the stock market as a source of funding for innovation by looking at the ability of the stock market to attract, identify and channel funds to innovative firms. We analysed 541 IPOs on the Swedish stock market between the years 2000-2015, using patent applications as a proxy for innovation. Results from an event study and regressions using two control groups show that firms find the stock market an attractive source of funding for innovation and that going public helps firms overcome liquidity restraints. By looking at the long- and short-term performance, measured by stock prices, of innovative firms by conducting OLS regressions, our results suggest; one, that there is an initial demand for innovative companies undergoing an IPO in comparison to non-innovative firms. And two, that investors are able to predict future innovativeness to some extent, but that they have some difficulties in anticipating future performance of innovative firms.

**Keywords:** innovation, IPO, going public, stock market, information asymmetry, signalling, underpricing, patents, patent applications

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# 1. Introduction

Innovation has been considered a crucial factor for economic growth and the development of society for nearly a century (Hasan and Tucci, 2010; Setayesh and Daryaei, 2017). For companies, the production of innovative new products and services lead to increased competitiveness, boosted sales, and hence increased firm value (Wies and Moorman, 2015; Zhou and Sadeghi, 2019). This in turn benefits society by promoting economic growth and therefore increasing the overall well-being and higher living standards within a country (Ahlström, 2010). Innovations, however, are neither a cheap nor a risk-free endeavour.

Firms may turn to the stock markets to fund their innovation activities by undertaking an *initial public offering*, commonly referred to as an *IPO* (Zattoni and Judge, 2012). Financial markets tend to be perceived to be more efficient compared to banks at allocating capital (Levine, 2002) and the proceeds of an IPO are commonly invested to promote growth and further development (Zattoni and Judge, 2012). For innovative companies, the capital raised by issuing shares to the public could thus undeniably be an important component for the funding of future innovation (Bernstein, 2015). Milhaupt (1997) claims the development of the stock market to have been an important factor for the level of innovation in the U.S economy. Similarly, Black and Gilson (1998) conclude that one of the benefits of a well-developed stock market is that it provides an easy exit for investors. This in turn, they reason, could be an incentive to invest in smaller innovative companies and start-ups that would otherwise have been avoided. This would then benefit the economy at large, since firms that succeed with innovation tend both to grow individually and have a positive effect on growth and development of society (Long, 2002; Ahlstrom, 2010).

However, for the stock market to be a valuable source of capital for innovative firms the market must be able to both attract innovative firms and identify them. Only then can the stock markets redistribute funds, in the form of savings from investors, towards innovative firms, so that the limited resources of the economy can be put to use where it will create the most value (Avgouleas, 2012). For this reason, this paper explored the relationship between the stock market and innovation by looking at, one; whether innovative firms prefer the stock market for funding, and if turning to the stock market boosts their level of innovation. And, two; if investors have the ability, and the willingness to select and channel funds to innovative firms. This was done by analysing 541 firms that underwent an IPO on the

Swedish stock market between 2000-2015, using patent applications as a proxy for innovation.

Theory states that it should make no difference for innovative activities in a firm whether the firm is private or public when financial markets have no friction (Bernstein, 2015). In a perfectly efficient market, the price of shares would be balanced between supply and demand and reflect all available information, and thus capital structure shouldn't affect innovation in firms (Avgouleas, 2012). However, all markets have some friction, and thus capital structure matters in practise. Consequently, going public increases access to capital which can then be used for innovation (Bernstein, 2015). Increased capital is especially vital for innovative firms since innovation tends to be particularly sensitive to financial restrictions (ibid.) On the other hand, the benefits of increased access to capital and the incentives to innovate might be undermined by the issues that can come from going public. By going public, the focus of both managers in the firm and the investors can turn towards short term profits and less risky innovation projects (Bernstein, 2015; Lee, 2020), which could impede innovativeness in the long run.

In our empirical work we found support for that going public helps innovative firms overcome liquidity restraints and to stay innovative in the long run. Furthermore, by comparing our results to similar firms that had filed for an IPO in the same period but ultimately withdrew the IPO before completion, it could be seen that innovative firms appear to prefer the stock market as a source of funding for innovation. This was further confirmed when we used regressions to compare the innovative firms undergoing an IPO with two control groups created through the *nearest neighbour matching* method.

Additionally, the difficulty in evaluating innovation, especially for outsiders, creates information asymmetry. This leads to investor uncertainty that can force innovative firms to compensate by setting a lower offering price (Long, 2002). Previous literature has provided no clear answers as to the connection between innovation and IPOs. Though there has been some research into the question in recent years it is still limited and with somewhat diverging results. For example, the evidence for the effect of innovation on IPO performance is not cohesive. On one hand, studies by Chin et al. (2006) and Useche (2014) show that the more innovative the firm the more likely the IPO is to be underpriced, this is reinforced by Guo, Lev and Shi (2006) and Zhou and Sadeghi (2019) who found that firms with more innovation input tend to be more underpriced. On the other hand, Long, (2002), Guo, Lev and Shi (2006)

and Zhou and Sadeghi (2019) also find that firms with more innovation output instead are less underpriced. Hence the previous evidence about how well the stock market can identify innovative firms is inconclusive. Our second set of results, using OLS regressions and stock prices to measure performance, provided evidence to support that innovative firms are generally more underpriced.

Nonetheless, despite drawbacks such as information asymmetry and the risk of underpricing, and hence missing out on capital, the stock market can be a cheaper option for capital compared to the debt market for innovative firms. For instance, turning to stock markets for funding means avoiding the evaluation costs that come with turning to bank credit (Zhou and Sadeghi, 2019). Stock markets can also provide investors with reliable information that they otherwise would not have been able to collect and process. Furthermore, patents have been argued to be able to signal innovativeness and thus mitigate information asymmetry (Long, 2002; Guo, Lev and Shi, 2006; Zhou and Sadeghi, 2019). However, though our results showed that investors have some ability to predict future innovativeness, these predictions do not seem to be based solely on patent history. Thus, patents neither work as a signal of value nor to mitigate information asymmetry. However, we further showed that patent information in a prospectus in connection to the IPO can increase investor demand.

When completing an IPO, the stock price of a firm is reflected by the supply and demand for the shares among investors, which in theory gives a reliable estimate of value that can tell investors where to put their savings to create the most value (Avgouleas, 2012). This is arguably especially valuable for innovative firms due to the difficulties in signalling the value of innovative activities (ibid.). However, this fact only holds true for innovation when the stock market can properly identify innovative firms. By looking at the long-term development of the firms undergoing an IPO we suggested that though investors tend to have an initial preference for innovation, they also in many cases have difficulties predicting the future performance of these firms. There is a great variation in the performance of innovative firms and hence investing in innovation might be a risk for investors. Despite this, funds are channelled towards innovation on the stock market.

This paper contributes to the literature about firm behaviour in relation to IPOs (Guo, Lev and Zhuo, 2004; Wies and Moorman, 2015; Lee, 2020), especially the relation between innovation and the decision to go public (e.g. Chin et al., 2006; Bernstein, 2015; Wies and Moorman, 2015; Lehmann-Hasemeyer and Streb, 2016; Zhou and Sadeghi, 2019).

Furthermore, it contributes to the literature about the effectiveness of financial markets (Black and Gilson, 1998; Lehmann-Hasemeyer and Streb, 2016), the literature about innovation after ownership change (Stulz, 1990; Faccio and Lang, 2002; Wagner and Cockburn, 2010; Wies and Moorman, 2015; Lee, 2020), and develop the literature about the signalling value and effect of innovative assets on investors and financial markets (Long, 2002; Guo, Lev and Zhuo, 2004; Chin *et al.*, 2006; Wagner and Cockburn, 2010; Deb, 2013; Useche, 2014; Bagnoli and Redigolo, 2016)**.**

The remainder of the study is structured as follows; part 2 of this study discusses theory and previous research, part 3 describes our data on IPOs, patents, prospectuses, and firms, and part 4 explains how the two control groups were constructed. Part 5 investigates the correlation between firms going public and patenting activities, and part 6 looks at the long-and short-term performance of innovative firms undergoing an IPO. Part 7 concludes the study.

## 2. Theory Review

### *2.1 The Stock-market and Innovation*

The stock market can be a source of funding for innovation. Innovation is an expensive and resource consuming matter and hence funding is important to both develop and sustain innovation (O'Sullivan, 2006; Hall and Lerner, 2010). In contrast to non-innovative companies (those that do not establish entirely new products or services), innovating firms generally have riskier business models (Lee, Sameen and Cowling, 2015). Intangible assets, like patents, are hard to use as collateral and potentially risky projects make it hard for banks to value the companies (ibid.). As a result, banks are more reluctant to lend money to innovative firms (c.f. Hutton and Nightingale, 2011). Stock markets, on the other hand, mitigates the risk of innovative activities by providing an easy exit for investors which encourages them to invest in innovative firms that may otherwise have been considered too risky (Black and Gilson, 1998). Because of this, stock-markets can be a valuable alternative for innovative firms to access capital. Previous studies show that though more innovative companies have a harder time accessing external funding, they are more likely than other companies to rely on external equity as a source of financing (Casson, Martin and Nisar,

2008; Lee, Sameen and Cowling, 2015). There is also some evidence that innovative firms perform better in the long-run than other IPO firms (Chin et al., 2006). Furthermore, one of the most vital functions of a financial system is to create a reliable estimate of value by filtering out private expectations and market-information through the process of supply and demand, i.e., market prices (Avgouleas, 2012). Going public by undertaking an IPO makes the shares of the company accessible for others to purchase (Zattoni and Judge, 2012), and in theory for a price that takes the firm's innovativeness into account. Thus, making it possible for investors to channel funds towards innovative firms and away from non-innovative firms.

There are, however, arguments for why stock-markets would not be able to capture innovative firms. One such reason being that successful private firms show that by remaining private, goals may remain clearer, and it may thus be easier to maintain and carry out innovation strategies (Lee, 2020). When a firm goes public, ownership and management is separated, which in turn can hinder strategies to be implemented (Stulz, 1990; Faccio and Lang, 2002), especially strategies involving risky innovation activities. Innovative firms may for this reason avoid going public.

Another factor that might affect the decision to go public is the market conditions. IPO markets have been shown to go through cycles of “hot” and “cold” periods (Helwege and Liang, 2004). A hot market is characterized by a cluster of IPOs and a higher level of underpricing, while cold markets have a lot less IPOs and a lower level of underpricing (Helwege and Liang, 2004; Subadar Agathee, Brooks and Sannassee, 2012). IPOs that are undertaken on a hot market also tend to lead to less negative returns. The reason for this being that hot markets lead to higher firm performance and shareholder value (Maung, 2014). This indicates that firms often wait to go public until the market conditions are favourable (Maung, 2014), which originates from a period of heightened investor optimism (Helwege and Liang, 2004).

### *2.2 Information asymmetry*

Even when innovative firms do go public, the investors on the stock markets could fail to identify them, or even avoid them, due to information asymmetries and uncertainty. The uncertainty could lead to phenomena such as underpricing where the initial price of shares is lower than the first day of trading’s closing price (Chin et al., 2006). Underpricing means missing out on capital, and though there are research that claims that investors rather tend to

be too optimistic about the future of IPOs (Ritter, 1998; Lehmann-Hasemeyer and Streb, 2016), other research found that underpricing is something innovative firms are at greater risk of (Chin *et al.*, 2006; Guo, Lev and Shi, 2006; Zhou and Sadeghi, 2019). This could be because innovative activities are difficult to evaluate and thus create information asymmetry (Long, 2002; Chin et al., 2006; Guo, Lev and Shi, 2006; Bessler and Bittelmeyer, 2008; Brito, Pereira and Vareda, 2016). Innovative firms that are just going public may not yet have a reputation to lean back on, which can force them to set a lower initial share price (Long, 2002). Innovative firms may even be more willing to underprice their IPOs and thus lose out on capital since they count on gaining it back once the market realizes the value of their innovative activities (Guo, Lev and Shi, 2006).

Furthermore, information asymmetry can also come from the separation of ownership and management when going public (Chin et al., 2006; Brito, Pereira and Vareda, 2016). The information asymmetry between managers and investors, combined with investors' claim for profit, might entice firm managers to manipulate stock prices instead of promoting long term innovativeness (Mizik, 2010). This is because when separating management and ownership, it is not unusual that managerial compensation is linked to the company's performance on the stock market (ibid.). For innovative firms, this might entail that investments in potentially risky innovative projects and R&D-expenditures are likely to decrease after a firm goes public, to instead further the financial performance and short-term earnings of the company (Long, 2002; Mizik, 2010; Wies and Moorman, 2015).

### *2.3 Patents as signal*

However, patents have been shown to be a valuable tool for decreasing information asymmetry between firms and investors, as it acts as a credible source of information that can be accessed by investors at a low cost (Long, 2002). Throughout the last decade, patenting has increased in number as companies try to protect their inventions and the corresponding benefits (Zhao, Xiang and Yi, 2017). By patenting an innovation, the company receives the legal rights of the invention which gives the owners of the patent the right to exclude others from making or selling the invention (Cambridge Dictionary, n.d.). By patenting, innovative firms can thus signal that they are creating value and will receive all the potential future profit from the patented innovation, which is especially useful for firms without established reputations (Long, 2002). However, evidence by Chin et al. (2006) found that patents do not raise the initial offering price and thus lower the underpricing, but rather signals that the IPO

is underpriced. Furthermore, Useche (2014) found that patents during the IPO process, such as in the prospectus, raise underpricing. This is contradicted by Guo, Lev and Shi (2006) and Zhou and Sadeghi (2019) who found evidence that while the uncertainty of R&D-expenditures leads to underpricing, a higher number of patents would instead moderate and lower underpricing for innovative companies undergoing an IPO. The reason for this being that while innovative input such as R&D-expenses in most cases are embossed with discretion and thus lead to information asymmetry between investors and the companies, information about innovative output, like patents, is more easily accessible for investors (ibid.).

This could indicate that the amount and precision of information disclosed before a company undergoes an IPO is of importance for investors' willingness to invest in innovative companies. Innovation is not a risk-free engagement and hence the information available to investors can have an effect on the success of the IPO. Tourani-Rad, Gilbert and Chen (2016) similarly argue that the more information disclosed and available to investors, the lower the information asymmetry and hence the lower risk to investors. Furthermore, it has been found that patents as a signal to investors before IPOs are positively correlated to market value (Wagner and Cockburn, 2010; Deb, 2013). However, the high disclosure requirements of an IPO may expose core technology, which might instead make innovative firms decide against going public (Guo, Lev and Zhuo, 2004). Many innovative firms are reluctant to disclose information about their intellectual properties as some types of innovation can lead to market uncertainties (Bagnoli and Redigolo, 2016). To avoid having to disclose information about this, innovative firms may prefer to stay private and/or to not patent their innovations. Patents may, however, mitigate the disadvantage of the disclosure requirements of an IPO by protecting the innovation (Guo, Lev and Zhuo, 2004). This way patents can also be used as a guide for investors as to where the firm's future activities are heading. Using patents to mitigate the information asymmetry at the time of an IPO might therefore increase investor's ability to identify innovative firms and willingness to invest in them.

### *2.3.1 Underwriting bank as signal*

In addition to patents, there are other factors that may signal value to outside investors as firms go public. One of them being the underwriter of the IPO (Carter and Manaster, 1990; Brau and Fawcett, 2006; Chin et al., 2006). A company may use the assistance of an underwriting bank to decide on an initial stock price, the number of shares and on which

stock market to list the shares (Zattoni and Judge, 2012). Some stock markets even have it as a requirement for their IPO firms. However, the underwriting bank requires emolument for its services and is therefore also a cost for a firm choosing to go public (Ritter, 1998; Bernstein, 2015). The need for an underwriting bank could thus be a reason for firms to choose to stay private, but it could also be an opportunity to influence the investors perception about the IPO (Carter and Manaster, 1990). Firms may use reputable underwriters to signal to investors that their IPO is low risk and of high quality, and as such good underwriter reputation has been linked to lower underpricing (Carter and Manaster, 1990; Brau and Fawcett, 2006; Chin et al., 2006). As investors have a perception that well renowned underwriting banks want to maintain their good reputation and thus not want to market too risky IPOs, the choice of underwriting bank becomes an important decision for companies deciding to go public (Carter and Manaster, 1990).

### *2.4 Summary of theory*

Consequently, due to the economic benefits to investors and the economy at large, stock markets should strive to channel funds to innovative firms and away from non-innovative firms. However, if the stock markets are successful in this or not is unclear, and subsequently the subject of exploration in this paper. As suggested by previous research, information asymmetry between owners and managers of the firms may create incentives that could impede innovation in the long run. It is therefore unclear whether an IPO does have any boosting or limiting effects on innovation. Furthermore, the difficulties of reliably evaluating innovation can create uncertainty among investors. Investor's ability to identify innovative firms may thus be impeded by information asymmetry. It has been suggested that patents can potentially be used to mitigate the information asymmetry and that way make investors more willing to invest in innovative firms. Whether going public does have any boosting effect on innovation, and whether investors on the stock market have the ability to identify and willingness to select innovative firms, thus remain empirical questions.

# 3. Data

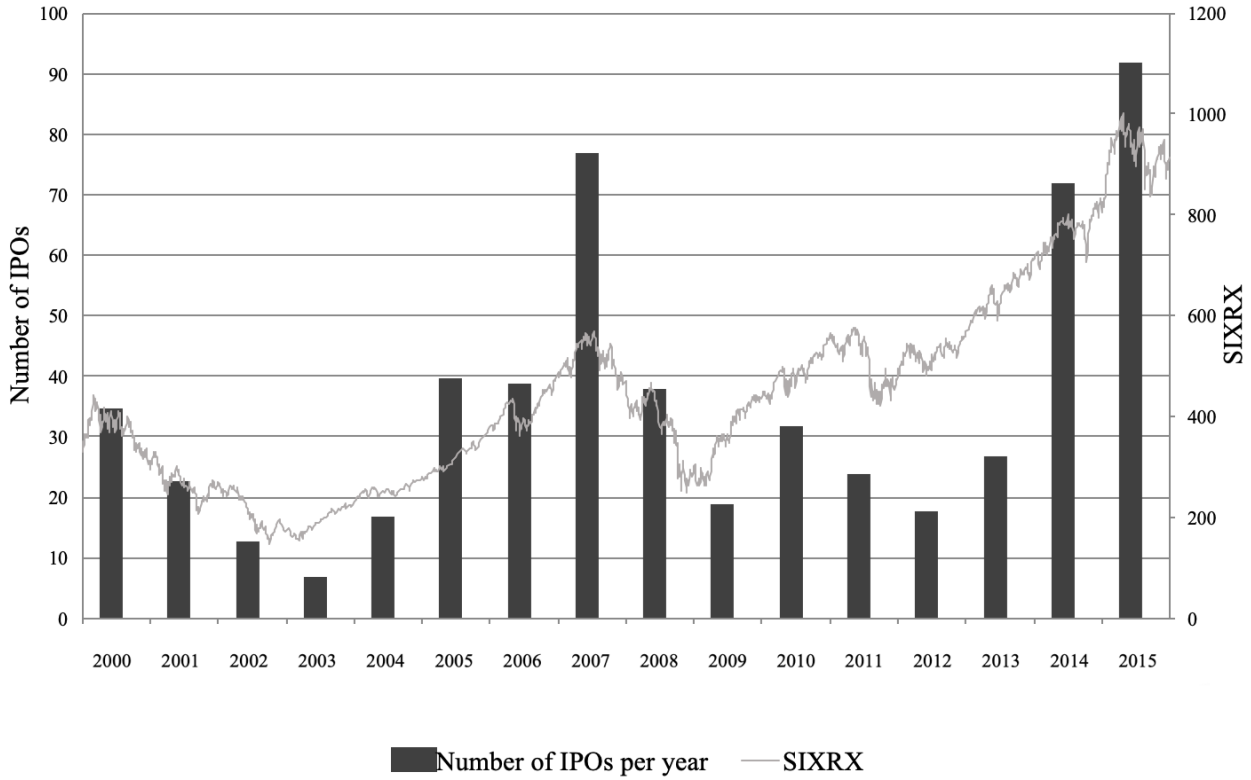
*3.1 IPO data*

In the study we collected data for all companies that went public in Sweden between 2000-2015 on Nasdaq OMX Stockholm, Nasdaq First North, Nordic Growth Market (NGM), and Spotlight. Data was retrieved from Refinitiv Eikon[1]. The study was limited to IPOs from the year 2000 at the earliest because information for all our variables becomes increasingly more difficult to find from earlier years. We included IPOs from the year 2015 at the latest since data was collected about each firm five years after the IPO, in accordance with earlier research (Bernstein, 2015; Lee, 2020; Wies and Moorman, 2015). Nasdaq OMX Stockholm and NGM Equity are the two only EU regulated equity stock exchanges in Sweden and are regarded as vital parts of the Swedish stock market. The two are thus to be considered of great importance for the study. In addition, the study investigated the somewhat less regulated Nasdaq First North and Spotlight. These markets are referred to as multi trading facilities (MTFs) and are important trading platforms for primarily small and medium sized companies in Sweden. Similar to a stock exchange an MTF is subject to regulation, but is not regarded as a traditional stock exchange market (Finansinspektionen, 2020). Following their somewhat looser regulations, many smaller and younger companies in a growing stage have a better chance to get listed on one of the MTFs than on Nasdaq OMX Stockholm or NGM Equity. As the study focused on innovation, both smaller and larger companies were of interest and thus both the main stock exchanges and the MTFs were chosen.

In 2000-2015 a total of 879 listings were made on the four stock-markets. We removed the firms that don't have a corporate identity number at the Swedish Tax Office since we needed that to find firm specific information. We further removed all secondary listings and spinoffs from the sample since the effects of investor's ability to identify innovative firms from their IPOs are likely to have been largely absorbed in the first listing. This left a dataset of a total of 541 unique Swedish IPOs for the years 2000-2015.

[1] Refinitiv Eikon is a provider of data for financial markets and infrastructures. The data is retrieved from over 2,000 sources and consists of among other factors real time stock market data, fundamental analytics and trading tools.

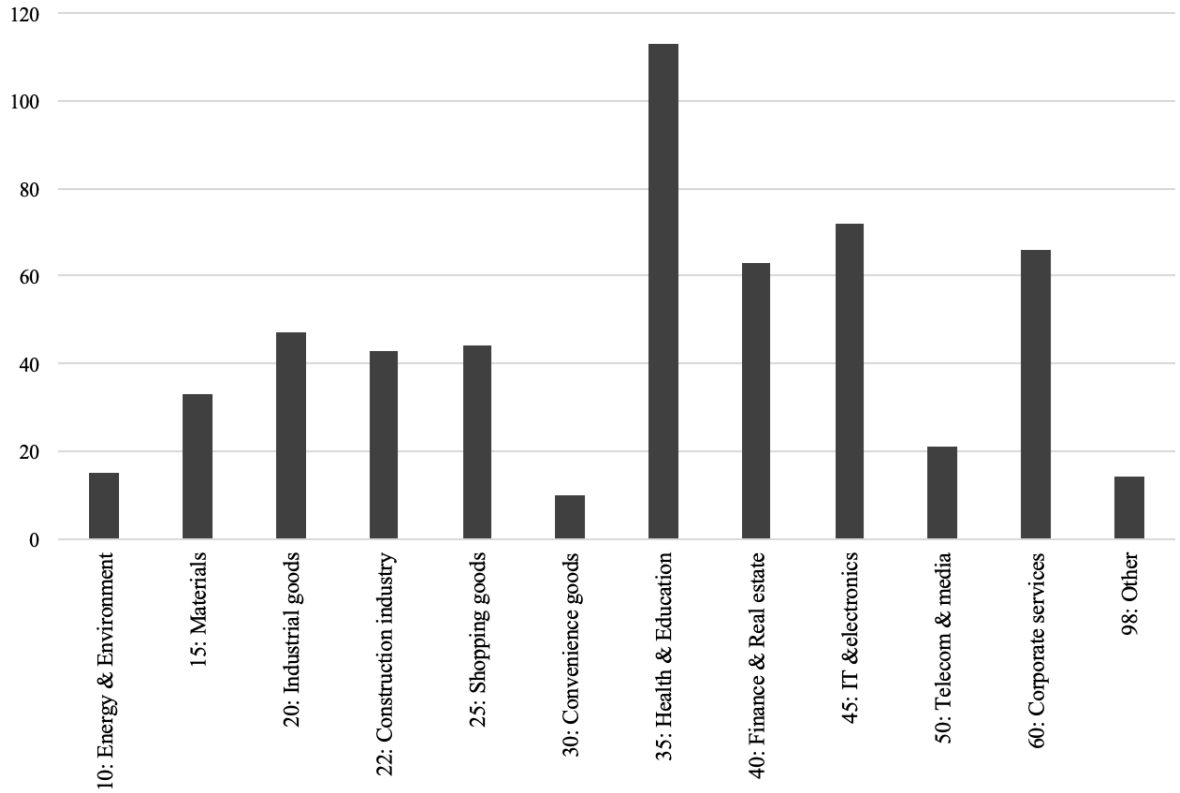
Figure 1: Number of IPOs per year
In relation to the development of the stock market




*Notes:* The number of IPOS per year in Sweden and the development of the index SIXRX, which reflects the development of the Swedish stock market.

The distribution of IPOs over the period showed that the number of IPOs increases and decreases in waves, similar to the movements of the market (see Figure 1). This can be due to the phenomena of "hot" and "cold" markets (Helwege and Liang, 2004; Subadar Agathee, Brooks and Sannassee, 2012; Maung, 2014). The fluctuations in the number of IPOs indicate that the year specific market conditions seem to affect the number of IPOs completed within a certain year.

Figure 2: Number of IPOs in each sector




*Notes:* The distribution of IPOs in different sectors between the years 2000-2015 on the Swedish stock market. The number before the sector name is the corresponding two-digit sector code.

In addition to the fluctuations in IPOs over the years, there are also differences in the number of IPOs between different sectors. Throughout the time frame in our study, the most IPOs occurred in firms in the sector Health & Education. This sector includes firms that offer education and health services, as well as firms that produce and sell medication and health products. The second most IPOs were in IT & Electronics, closely followed by Corporate services and Finance & Real estate.

### *3.1.1 Withdrawn IPOs*

To get a comparable group for our IPO data to use as a control group (see section 4), we also collected data on firms that filed for an IPO but withdrew it before completion. We collected data for the same period as for our firms completing an IPO, 2000-2015. The only organization that collects data on withdrawn Swedish IPOs, as far as we were aware, is nyemissioner.se[2]. However, since many IPOs and corresponding prospectuses remain

[2] A web page operated by Börsforum Sverige AB that has data about Swedish IPOs and rights issues dating back to 2001.

confidential until the decision to go public has been finalized, many of those that are withdrawn are never made public and can thus not be found on nyemissioner.se. Furthermore, the earliest data on the site is from 2001 and the data from the first few years is not complete. Since we needed to match our withdrawn and our IPO firms, we also had to exclude those that had not set a year for their IPO before cancelling it. For this reason, our sample was quite small, consisting of 211 unique firms withdrawing their IPOs before completion.

#### *3.1.2 Underwriter*

Additionally, information about the *underwriting bank* was gathered. The underwriting bank might have signalling value, as discussed above, and is therefore often an included variable (see Brau and Fawcett, 2006; Guo, Lev and Shi, 2006; Deb, 2013; Bernstein, 2015; Lehmann-Hasemeyer and Streb, 2016). Data regarding the underwriter was mainly found in the prospectuses retrieved from Finansinspektionen, the trading platforms and the individual firms directly. The underwriter dummy was given a value of 1 if the main underwriter used for the IPO was ranked as a top underwriter by Kantar Sifo[3] for the corresponding year, and a value of 0 if not. If a ranking wasn't available for that year, we employed the ranking of the most proximate year. Due to missing data the sample of IPOs was reduced from 541 to 462 companies for this variable.

### *3.2 Patent data*

As a proxy for the level of innovation within the companies in our sample, the number of patent applications was used. Throughout previous literature, patents have been widely used as an indicator of innovation within firms (Bernstein, 2015; Burhan, Singh and Jain, 2017; Lee, 2020; Zhao-Jansson and Andersson, 2020). It has, though, been questioned to what extent patents and innovation are correlated, since for example, some aspects of innovation have been argued not to be captured by the patents of a company (Arundel and Kabla, 1998). However, patent applications are thought to be a fairly reliable proxy for the level of innovation within a company as it could be seen as a way to measure the output of innovating activities (Burhan, Singh and Jain, 2017). In this study, the number of patents of a company refers to the number of *patent applications* of that company. This number does not necessarily correspond to the number of *patents granted* for that specific company. However, patent applications are thought to be made when a company estimates the potential future

[3] Sweden's largest analysis- and market research company. Owned by Kantar which is one of the world leaders in business- insights, analysis and consulting.

benefit of an invention to be worth protecting from imitation, whereas a patent grant can come several years later (Xiao, Wu and Kim, 2021). Hence, patent applications are thought to be more time-accurate than granted patents and reflect the level of innovation within a company and were thus used as a proxy for innovation throughout the study.

Patent information was retrieved from PATLink[4], Espacenet[5] and the Swedish Intellectual Property Office's Swedish Patent Database[6] for all companies undergoing an IPO between the years 2000-2015 on the Swedish market. Patent data was also retrieved for innovative private firms and for firms that withdrew their IPO from the Swedish stock market before completion, in order to construct control groups to be able to draw conclusions about the effect of going public on innovation (see section 4). Bernstein (2015), Lee (2020) and Wies and Moorman (2015) all collected data from three years before to five years after the year of the IPO, and we followed this approach. We then matched patenting firms with Swedish corporate identity numbers by using the PATLink dataset. To avoid missing values, we used the natural logarithm of the annual count of patent applications plus one. Table 1 shows an overview of the patenting activities of the IPO firms in our sample.

Table 1 - Patenting Activities of IPOs at the Stockholm stock market between 2000-2015

| | Total | Percentage of all 541 IPOs |
|---|---|---|
| All firms with patent applications | 196 | 36.2 |
| Firms with patent applications before the IPO | 128 | 23.7 |
| Firms with patents application at the year of IPO | 86 | 15.9 |
| Firms with patent applications within 5 years after IPO | 161 | 29.8 |
| Firms with patent applications before and within 5 years after IPO | 116 | 21.4 |

*Notes:* statistics of the number of patent applications made around the event of an IPO.

### *3.2.1 Prospectus data*

To retrieve data about how firms present and use their patents in their IPOs, we scoured through each prospectus for the 196 firms with patents in our sample. For companies listed on

[4] PATLink provides data where patent and trademark information are matched to organizations. The data includes data for patents owned by Swedish firms over the years 1990-2018. PATLink is financed by Vinnova and its patent data is retrieved from PATSTAT and corporate information from SERRANO.
[5] Espacenet is an online database providing information about more than 90 million patent and patent applications. Responsible for Espacenet are the European Patent Office and the European Patent Organisation.
[6] The Swedish Patent Database provided by the Swedish Intellectual Property Office is an online database which covers Swedish patents and patent applications including bibliographic data, legal status and information about registration among other records.

the main stock markets; Nasdaq OMX Stockholm and NGM Equity, the prospectuses were mainly retrieved from Finansinspektionen since they have a register of all approved prospectuses from late 2006 in Sweden. By contacting Finansinspektionen, we were also able to collect approved prospectuses from their archive for companies undergoing an IPO on the main stock markets from the year 2000 and forward. For the companies not having registered their prospectus at Finansinspektionen, mainly companies listed on the MTFs, the prospectuses were retrieved either from the trading platforms or directly from each company, either through their websites or by contacting the companies.

To begin with, we looked at whether the innovative firms referred to their patents or not in their prospectuses. Then, depending on how the firms promoted patenting in their prospectuses, we categorize the firms as either *mentioning* their patents and/or patent applications or *advertising* them in their prospectuses. We determined the patents and/or patent applications as being used for advertising when the firm, for example, used their patents, patent applications or patent strategy as a selling point of the firm in the firm description. Another example of firms using patents to advertise the IPO were firms that consistently described their operation and products by denoting them as being patented. Our definitions of *mentioning* and *advertising* patents are subjective, but we choose to include them since patents that are advertised might send stronger signals to investors than patents that are just mentioned. Due to missing data the sample was reduced from 196 to 177 firms for these variables.

### *3.4 Stock data*

To measure performance, we used stock data from Refinitiv Eikon. The short-term performance of the companies undergoing an IPO was measured by looking at the underpricing of the IPO. Descriptive statistics about underpricing in innovative firms undergoing an IPO is shown in Table 2. However, due to lack of data about the offering- or initial closing price for, primarily, the companies from the early 2000s, the sample of innovative firms was reduced from 196 firms with patents to 154 when looking at their short-term performance, and the total sample of IPOs from 541 to 331.

The long-term performance of the companies was established by measuring the development of the stock price throughout the five consecutive years after the IPO[7]. In Table 2, statistics

[7] Five years was approximated as 1260 trading days, translating into 252 trading days a year.

about the long-term performance in innovative firms is shown, both unadjusted and adjusted against the benchmark index SIX Return Index (SIXRX) representing the development of the Swedish stock market including dividends. Due to missing data, 146 innovative firms and 289 firms without patents remained, giving us a final sample of 435 firms for this variable. After observing a potential outlier by plotting the data, the Grubbs' test was used to control for outliers in the sample (Grubbs and Beck, 1972). Based on the Grubbs' test at an upper 0.1% significance level, one outlier was removed to make the final data sample for the long-term performance variable 434, whereof 145 firms were innovative (see appendix, Table A.9).

Table 2 - Descriptive Statistics Long-and short-term Performance

| | Underpricing | 5 year development of share price | 5 year development of share price adjusted against benchmark index |
|---|---|---|---|
| Mean: | 15.61% | 80.07% | 30.34% |
| Median: | 5.08% | -21.97% | -66.62% |
| St. Dev: | 42.01% | 320.41% | 34.75% |
| Min: | -82.50% | -99.42% | -267.70% |
| Max: | 230.00% | 1931.01% | 1870.49% |
| Observations: | 156 | 145 | 145 |

*Notes:* Statistics about the underpricing and long-term performance of the firms with patents that went public between 2000 and 2015. A negative number in column one indicates overpricing, while a negative number in column two and three indicates a smaller development than SIXRX.

### *3.6 Firm level data*

Finally, we collected some firm level data from Refinitiv Eikon. Specifically, for the variables *Age of Firm* and *Denoted within 5 years*, that we used in our regressions, and *total assets* which we used when constructing our control groups of private and withdrawn firms (see section 4). For the private firms and withdrawn IPO firms where data could not be found on Refinitive Eikon, the database Retriever Business[8] and the companies' annual reports were used to gather data about *total assets*. *Age of firm* was included as a variable since it has been found that older firms tend to perform better both before and after an IPO in comparison to younger firms (Ritter, 1998; Filatotchev and Bishop, 2002). The age was calculated as the number of years since the firm was founded until the time of the IPO. Due to some missing data points, there were 329 firms out of 541 for this variable. The other variable, *Denoted*

[8] Retriever Business is a database with information about Swedish companies from the year 2000 and onwards.

*within 5 years*, was used to check for if a firm exited the market in the following five years after the IPO (c.f. Bernstein, 2015). This would indicate whether the stock market was able to identify firms that succeed. If the firm exited the market in the five years following the IPO it was given the value of 1, otherwise it was given the value of 0.

Table 3 - Summary Statistics

| | All IPOs | | | Innovative firms | | |
|---|---|---|---|---|---|---|
| | Mean | Median | St.dev | Mean | Median | St.dev |
| **Firm characteristics** | | | | | | |
| Age of firm | 10.47 | 7.00 | 15.96 | 11.24 | 7.00 | 16.06 |
| Denoted within 5 years | 0.19 | 0.00 | 0.39 | 0.12 | 0.00 | 0.32 |
| Top ranked underwriter | 0.17 | 0.00 | 0.38 | 0.17 | 0.00 | 0.38 |
| **Patent applications** | | | | | | |
| 3 years before IPO | 3.37 | 0.00 | 15.62 | 9.29 | 2.00 | 24.89 |
| 5 years after IPO | 5.99 | 0.00 | 34.05 | 16.49 | 3.00 | 55.05 |
| Over investigated period | 6.23 | 0.00 | 34.33 | 8.42 | 1.00 | 39.68 |
| **Patents referred to in prospectus** | | | | | | |
| Patents mentioned | | | | 0.31 | 0.00 | 0.46 |
| Patents advertised | | | | 0.52 | 1.00 | 0.50 |

*Notes:* The variables *Denoted within 5 years* and *Top ranked underwriter* takes a value of 1 or 0 depending on whether the firm is denoted and if a top ranked underwriter was used as the primary advisor. Displayed are thus the mean as a percentage of firms being denoted and having a top ranked underwriter and the median as the most common value of 1 and 0 for these variables.

## 4. Constructing the control groups

We constructed two control groups. The first control group consisted of firms that initially decided to go public but eventually withdrew their IPO before it was completed. As these firms had decided to undergo an IPO in the same year as the firms in our sample that underwent an IPO, they are assumed to have been in a similar stage in the corporate lifecycle. Including these firms as a control group should remove potential biased estimates from firms deciding to go public as a natural stage in their corporate life cycle (Bernstein, 2015). The reason for these firms staying private could be because their IPO did not induce enough interest from investors. Out of our sample of 211 firms with withdrawn IPOs only a fraction had patent applications within the three years before to five years after the planned IPO (see Table 4).

Table 4 - Patenting Activities of withdrawn IPOs at the Stockholm stock market

| | Total | Percentage of all 211 withdrawn IPOs |
|---|---|---|
| All withdrawn IPOs with patents | 23 | 10.9 |
| Firms with patent applications before withdrawn IPO | 17 | 8.1 |
| Firms with patent applications at the year of withdrawn IPO | 13 | 6.2 |
| Firms with patent applications within 5 years after withdrawn IPO | 14 | 6.6 |
| Firms with patent applications before and within 5 years after withdrawn IPO | 11 | 5.2 |

*Notes:* Statistics of the number of patent applications made around the set date of an IPO that was withdrawn from the Swedish stock market before completion. Due to limited access to information, most of the withdrawn IPOs had a set date in the latter half of the investigated period.

Due to the small sample of withdrawn IPOs, it might be difficult to draw conclusions from it. Therefore, a second control group consisting of innovative private firms was also constructed, consisting of private firms that had not filed for an IPO within the investigated period. The drawback of this second control group is that there is no way to determine when these firms would have chosen to go public, and thus which should be the "IPO year" when matching with our firms undergoing an IPO. This makes it more difficult to isolate the effects of the IPO. By including both control groups, we could thus give a fuller picture.

To mitigate the effects of factors influencing innovation in firms other than the event of an IPO, and to alleviate selection bias, the *nearest neighbour matching* approach was used to create the control groups. The nearest neighbour approach matches individuals from a control group to the treatment group and disregards the individuals that are not matched (Stuart, 2010). Thus, for each firm in the treatment group, the one firm most similar with regards to the chosen variables were chosen from the population of innovative private firms, and the population of withdrawn firms respectively, to construct the control groups. The firms in the two control groups met the three following criteria: (1) the number of patents for the IPO year and the three years prior are each in the ±50% bracket of patents for the target company, (2) it belongs to the same two-digit sector as the target company, and (3) the natural logarithm of total assets (*LnAssets*) the year of the IPO is in the ±50% bracket of the LnAssets of the target company. We used the logarithm of total assets (*LnAssets*) measured at the time of the IPO

filing as a proxy of firm size (Useche, 2014; Bernstein, 2015; Zhou and Sadeghi, 2019b; Lee, 2020), since it has previously been shown that larger firms have less information asymmetry (Barth and Kaznikc, 1999, cited in Bernstein, 2015). As information asymmetry could affect innovativeness and underpricing, as discussed above, we matched firms of similar size. By using the nearest neighbour approach, selection bias in the matching process was reduced. However, despite being an efficient way to match the control group to the treatment group there are limitations with nearest neighbour matching. Stuart (2010) highlights the fact that with this approach a large number of observations might be discarded due to the 1:1 matching, which would lead to leaving out potentially important information. Furthermore, the matching is limited to a small number of criteria, while there might be several other factors affecting the level of innovation that are not controlled for in the matching process.

Using the nearest neighbour matching approach, we were left with a control group of 12 firms with withdrawn IPOs, a rather small sample size and thus a limitation for the study, and an additional control group of private firms consisting of 91 unique firms.

# 5. The correlation between going public and patenting activities

## *5.1 Patenting activity*

To understand the stock exchange as a market for innovation, we first looked at what effect the stock market has as a source of funding on the level of innovation in firms, and whether innovative firms prefer the stock market for funding. We started by exploring the number of patent applications over time around the event of the IPO, to see whether going public had any effect on the amount of patent applications in firms, by constructing an event study. To do this we used panel data of patent applications over time, from three years before to five years after the IPO for all firms undergoing an IPO between the years 2000-2015, as well as for only the firms with at least one patent in our sample. Separate dummy-codes were used for each of the three years prior to and five years following the IPO event, leaving the year of the IPO as the omitted category. This was done to remove time-trends, such as the effects of hot and cold markets. An event study was then executed with the following baseline equation:

$$\text{Patent applications} = \alpha + \beta_1 \text{IPO}_{-3} + \beta_2 \text{IPO}_{-2} + \beta_3 \text{IPO}_{-1} + \beta_4 \text{IPO}_{+1} + \beta_5 \text{IPO}_{+2} + \beta_6 \text{IPO}_{+3} + \beta_7 \text{IPO}_{+4} + \beta_8 \text{IPO}_{+5} + \gamma_i \text{Y}_i + \epsilon \quad (1)$$

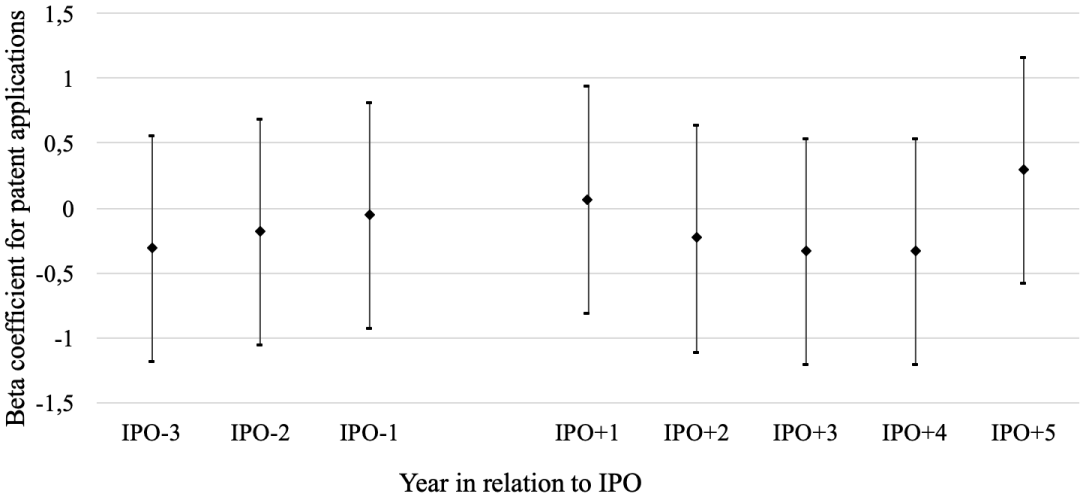
Where (*Y*) is the dummy variable for the IPO years that control for year effects and (i) is indexing the years, i=1,...15. The term $\epsilon$ is an error term which represents the difference between the actual patent application numbers and the number of patent applications expected by the regression. Each dummy ($IPO_{-1}$ to $IPO_{+5}$) was set to take the value of 1 for only one year to isolate that specific year. For example, the dummy $IPO_{+3}$ takes the value of 1 three year after that the firm underwent an IPO and the value of 0 all other years. This means that for a firm that underwent an IPO in 2010, the dummy $IPO_{+3}$ had the value of 1 for 2013 only, while it had the value of 1 in 2008 for firms that underwent an IPO in 2005. This approach made it possible to compare innovation before and after an IPO for firms that went public in different years. The reason for this was to examine whether the level of innovation was affected by the firm going public, and the results can be viewed in Table 5, as well as in Figure 3 and 4.

Table 5 - Patenting Activities 3 years before to 5 years after the IPO Event

| Patent Applications | | |
|---|---|---|
| Sample | All IPOs | IPOs |
| Model: | 2000-2015 | with patents |
| | (1) | (2) |
| IPO - 3 years | -0.305 | -0.842 |
| | (0.376) | (1.009) |
| IPO - 2 years | -0.179 | -0.495 |
| | (0.361) | (0.961) |
| IPO - 1 year | -0.054 | -0.148 |
| | (0.333) | (0.878) |
| IPO + 1 year | 0.068 | 0.189 |
| | (0.378) | (1.003)) |
| IPO + 2 years | -0.229 | -0.633 |
| | (0.340) | (0.904) |
| IPO + 3 years | -0.333 | -0.918 |
| | (0.342) | (0.913) |
| IPO + 4 years | -0.333 | -0.918 |
| | (0.403) | (1.085) |
| IPO + 5 years | 0.294 | 0.816 |
| | (0.636) | (1.732) |
| Constant | 1.301*** | 3.592*** |
| | (0.249) | (0.657) |
| Observations | 4,869 | 1,764 |
| $R^2$ | 0.001 | 0.002 |
| Year dummies | Yes | Yes |
| Number of firms | 541 | 196 |

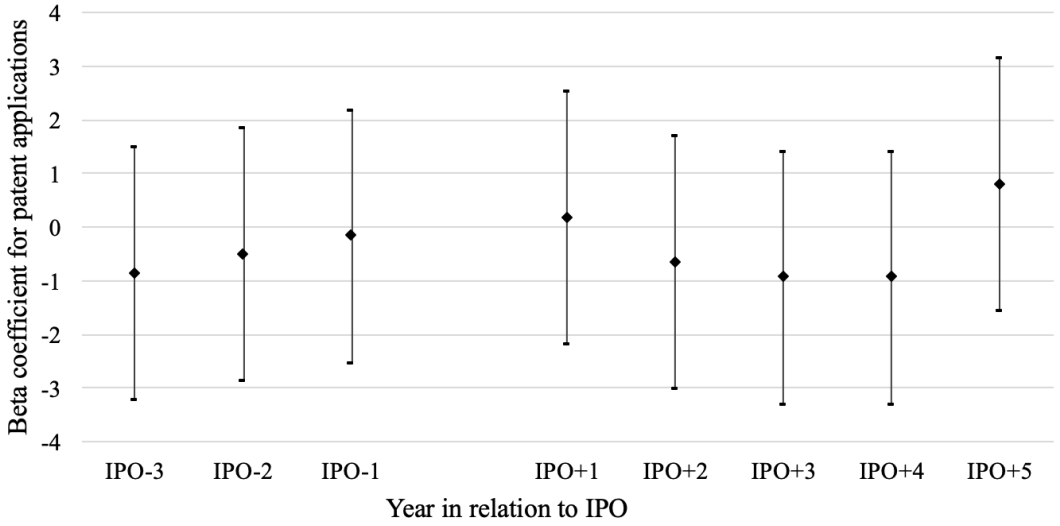
*Notes:* In both regression (1) and regression (2) the dependent variable is the number of patent applications. The years are set to dummy variables, where the omitted year is the year of the IPO. The model is based on panel regressions and displayed are the beta coefficients, and within parentheses are the robust standard errors. *** indicates that the coefficient is statistically significant at a 1% level.

Figure 3: Patent applications around the IPO event
(All IPOs 2000-2015)




*Notes:* Beta coefficients corresponding to year dummies in regression (1) in Table 2 and their respective 95% confidence intervals.

Figure 4: Patent applications around IPO event
(IPOs with patents 2000-2015)




*Notes:* Beta coefficients corresponding to year dummies in regression (2) in Table 2 and their respective 95% confidence intervals.

Table 5 shows negative beta coefficients for all three years prior to the IPO for both samples (Table 5 (1) and (2)), but they become smaller the closer they are to the year of the IPO. This is further illustrated in Figure 3 and 4, which plot the beta coefficients corresponding to the regressions in Table 5 and their respective 95% confidence intervals. This indicates that firms tend to apply for more patents leading up to an IPO. This could possibly be because firms end up going public after innovative breakthroughs and/or large spendings on innovative

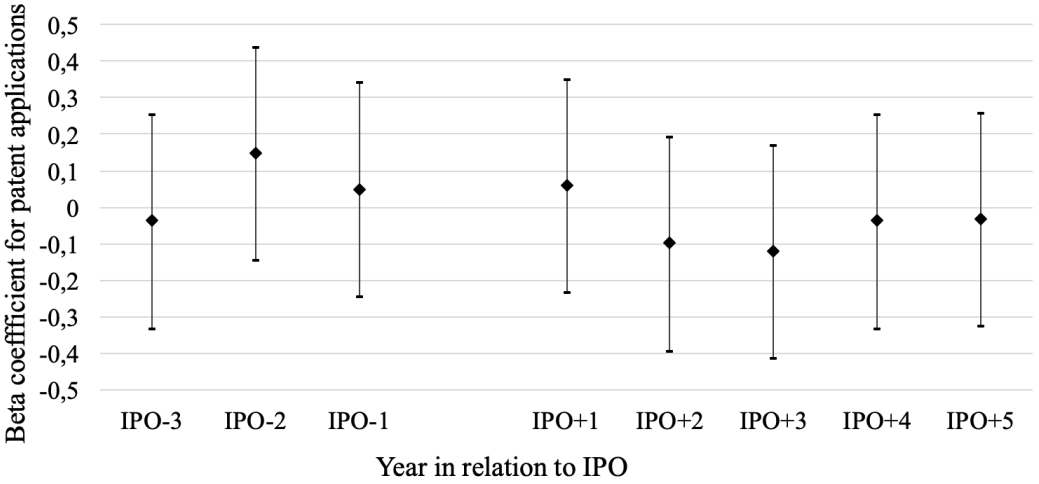
investments. The first year after the IPO has positive beta coefficients, but the following three years have negative beta coefficients. The negative trend could be due to the fact that the capital from the IPO is used for promotion of the firm and/or innovative activities which don't give immediate results. Four years after the IPO, the negative trend has become smaller, and by year five after the IPO the trend has turned and become positive, notably also higher than in the years leading up to the IPO. These results show a similar trend as found by Wies and Moorman (2015). This indicates that funding from an IPO takes about five years to show results in firm innovation, but that going public does help firms stay innovative in the long run and overcome their liquidity restraints. This contradicts the argument that information asymmetry between managers and investors, as well as investors' claim for profit, lead to managers focusing on short-term earnings after an IPO, resulting in decreased innovativeness long-term (Long, 2002; Mizik, 2010; Wies and Moorman, 2015). Hence, the funding from investors channelled to innovative firms appear to be used effectively to promote innovative activities in the long run.

However, this model cannot give a full explanation of the relationship between innovation activities and IPOs since we don’t know how much of the proceeds from the IPO went to innovation activities. It is also impossible to say how many of the patents a firm would have applied for if they had chosen to remain private. Furthermore, since none of the coefficients in table 5 were significant we were cautious about drawing conclusions without further evidence. For this reason, we look at firms that have decided to remain private by withdrawing a planned IPO.

### *5.2 Withdrawn IPOs*

By looking at firms that initially decided to go public but eventually withdrew their IPO before it was completed, we could contrast our findings for firms undergoing an IPO. The small sample size could be considered a limitation for the study, but despite its size, the sample can nonetheless give a picture of the firms that began the process of going public but ultimately decided to stay private.

Figure 5: Patent applications around IPO event
(Withdrawn IPOs)




*Notes:* Average number of patent applications around the planned IPO year for firms that withdrew their IPO before completion and their respective 95% confidence intervals.

As can be seen in Figure 5, in contrast to the firms that did go public, patenting for the withdrawn IPO firms went down in the year leading up to the IPO, implying that investors prefer more innovative firms. Furthermore, the withdrawn firms did not get the upswing of patent applications at year five after the IPO that the firms that went public did. This gives further evidence that the stock market helps mitigate the liquidity restraints of innovation. This is highlighted by the fact that the percentage of firms in the sample that has patents during any of the nine years (see Tabel 4) is less than a third compared to in the sample of firms that go public (see Table 1). This indicates that innovative firms do prefer the stock market as a source of funding for innovation.

*5.3 Control groups*

To further investigate the relationship between going public and innovation, a regression for all IPOs was constructed with the following baseline equation:

$$\text{Patent applications} = \alpha + \beta_1 \text{GP} + \beta_2 \text{GPxY} + \beta_3 \text{Year} + \epsilon \qquad (2)$$

The regression allowed us to see the effects of going public on patent applications and also to study how patenting is affected by year specific effects. *Going public (GP)* is a dummy variable that takes the value of one for the year of an IPO and the following years after the IPO. By deploying this variable, we were able to determine whether the number of patent

applications decreased or increased after the event of an IPO. *Going public x year (GPxY)* is an interactive variable that divides the patent applications after an IPO between the different years. This variable is the product of the variable *Going public (GP)* and the years following an IPO (*Y*) where the year of the IPO is set to 0, the year after the IPO is set to 1 etc. The reason for this variable was to determine if the number of patent applications changed over the time depending on how many years had passed since the IPO. The variable *Year* shows the temporal effect over the years in our study and is set to 0 for the year 1997 (since this is the earliest year for patent data in our sample) and increases with 1 for each of the consecutive years up to 2020. $\epsilon$ is the error term.

Three additional regressions were included. The first one compared all IPOs in our sample with our control group of innovative firms that remained private throughout the whole period and not filed for an IPO in the years 2000-2015, i.e. our control group of innovative private firms. The second and third regression then compared the treatment group of innovative firms undergoing an IPO with the two control groups; firms with withdrawn IPOs, and the innovative private firms. The equation for these three regressions were as follows:

$$\text{Patent applications} = \alpha + \beta_1 \text{GP} + \beta_2 \text{GPxY} + \beta_3 \text{IPOxYear} + \beta_4 \text{Year} + \epsilon \qquad (3)$$

The variable *IPO* is a dummy variable set to 1 for all the innovative firms that underwent an IPO and set to zero for all the firms remaining private throughout the period. Hence the interactive variable *IPO x Year (IPOxYear)* is a product of the variables *IPO* and *Year* and divides the patenting activities between firms going public and firms that remain private taking into consideration temporal changes. This showed whether the difference in patent applications for private firms and firms that go public had diverged over time.

Table 6 - Patenting Activities 1997-2020: IPOs versus Private Firms

| Sample: | All IPOs (2000-2015) | All IPOs (2000-2015), IPOs versus private | Innovative firms, IPOs versus private | Innovative firms, IPOs versus withdrawn |
|---|---|---|---|---|
| Dependent variable: | Patent applications | Patent applications | Patent applications | Patent applications |
| | (1) | (2) | (3) | (4) |
| Going public (=1 if year $\geq$ year of IPO) | 0.371 | 0.267 | 0.912 | 0.809* |
| | (0.293) | (0.287) | (0.968) | (0.435) |
| Going public x year (year of IPO =0) | 0.150* | 0.172** | 0.789*** | 0.153 |
| | (0.078) | (0.077) | (0.261) | (0.118) |
| IPO x Year (1997=0) | | -0.042* | -0.093 | -0.026 |
| | | (0.024) | (0.057) | (0.021) |
| Year (1997=0) | -0.146*** | -0.125*** | -0.244*** | -0.127*** |
| | (0.022) | (0.026) | (0.051) | (0.041) |
| Constant | 2.582*** | 2.948*** | 4.657*** | 2.665*** |
| | (0.285) | (0.255) | (0.620) | (0.711) |
| Observations | 4869 | 5688 | 1638 | 216 |
| $R^2$ | 0.009 | 0.012 | 0.026 | 0.067 |
| Number of firms | 541 | 632 | 182 | 24 |

*Notes:* Displayed are the beta coefficients and their respective standard error within parentheses. *, ** and *** indicate that the coefficient is statistically significant at a 10%, 5% and 1% level respectively.

Model (4) in Table 6 comparing withdrawn innovative IPOs and innovative firms completing an IPO shows that there is a weakly significant positive correlation between a firm going public and patent applications. Likewise, the models (1)-(3) indicate a positive correlation for the coefficient *Going public*, however these results are not on a statistically significant level. The positive effects of going public on innovation furthermore seems to become larger as the temporal distance to the year of the IPO grows, as shown by the significant positive coefficients of the variable *Going public x year* in column (1)-(3). This indicates that going public does increase the number of patent applications a firm can produce and that the effect is greater some years after the IPO, confirming our earlier results that it takes some years for the funding to produce results in innovation. Furthermore, the weakly significant variable *IPO x Year* indicates that the difference in number of patent applications between private and IPO firms have decreased in the last couple of decades, implying that the benefits to innovativeness from going public may have decreased slightly (although, this variable is only significant in column (2)). The negative coefficient for the variable *Year* shows a negative correlation with patent applications, indicating that the number of patent applications has decreased over the years 1997-2020. Overall, the results in Table 6 conform with our earlier findings and show that the decision to go public favoured long-term innovativeness in firms.

By taking the results from our event study, the withdrawn IPO firms, and the regressions comparing the firms undergoing an IPO with the control groups together, we draw the conclusions that innovative firms prefer the stock market for funding, supporting evidence by Casson, Martin and Nisar (2008) and Lee, Sameen and Cowling (2015), and that going public mitigates the liquidity restraints of innovativeness in the long-run.

## 6. Short-term and long-term performance

### *6.1 Short-term performance*

The next step in our analysis was to turn the focus towards the preferences of investors on the stock market, by exploring whether investors prefer innovative firms to non-innovative firms (the firms without patent applications in our data). To do this, we analysed underpricing with the help of initial offering- and stock prices. By looking at the short-term performance of the IPO, the demand for shares when the companies initially went public was determined. A high

underpricing implies that the shares could have been priced higher and indicates a strong demand to invest in the newly listed company (Lehmann-Hasemeyer and Streb, 2016). The underpricing was calculated as follows:

$$\text{Underpricing} = \frac{(P_{first} - P_{offering})}{P_{offering}} \tag{4}$$

$P_{first}$ represents the closing price of the stock on the first day of trading, and $P_{offering}$ represents the offering prices at which the shares were initially offered to the market in the IPO.

To see whether investors had different preferences for, and could distinguish between firms with different levels of innovation, we divided the sample of innovative firms into groups. Similarly to Lehmann-Hasemeyer and Streb (2016), we divided the companies into three different groups depending on their patenting activities. We created three mutually exclusive categories and distinguished *Permanently innovative* firms as companies that applied for patents both during the three years before, or at the year of the IPO, and within five years after the IPO. There was a total of 116 permanently innovative firms and these can be considered to perform innovating activities both before and after the decision to go public. Furthermore, we classified companies that had no patent application in the three years before, or at the year of the IPO, but that made one or several patent applications within the five consecutive years after the IPO as *Innovative start-ups*. Innovation in these companies is thought to be dependent on financial means from investors and thus patent applications were made after the firm went public (Lehmann-Hasemeyer and Streb, 2016). In our sample there were 45 innovative start-ups. The last group is referred to as the *Facits*[9] and are companies that had one or several patent applications within three years before, or at the year of the IPO, but that made no patent applications during the five years after the IPO. There were 35 Facits in our sample. For these companies, the decision to go public did not enhance innovation and was arguably a bad investment.

[9] Facit AB was a highly innovative and successful Swedish company that manufactured mechanical calculators and typewriters. When the electronic calculator entered the market in the early 1970s, Facit failed to stay innovative, and ultimately collapsed (Sandström, 2013).

The sample of non-innovative firms was used as a benchmark category. Ordinary least square (OLS) regressions with robust standard errors were conducted and the baselines were as follow:

$$\text{Level of Underpricing} = \alpha + \beta_1 \text{PI} + \beta_2 \text{StartUp} + \beta_3 \text{Facit} + \gamma_j \text{S}_j + \epsilon \tag{5}$$

$$\text{Level of Underpricing} = \alpha + \beta_1 \text{PI} + \beta_2 \text{StartUp} + \beta_3 \text{Facit} + \beta_4 \text{DF} + \beta_5 \text{UW} + \beta_6 \text{AF} + \gamma_i \text{Y}_i + \gamma_j \text{S}_j + \epsilon \tag{6}$$

Where *Level of Underpricing* shows how much the closing price of the first day of trading differed from the initial offering price. *PI, StartUp* and *Facit* are the dummy variables that divide the results between Permanently innovative firms, Innovative start-ups and Facits. Both models also checked for sector effects by applying sector dummy variables (*S*), where (j) is indexing sectors, j = 1...,11. Regression (6) also took into consideration the effects of a firm being denoted from the market within the following 5 years after the IPO (*DF*), the reputation of the underwriter for the IPO (*UW*), and the age of the firm (*AF*). This model also controlled for IPO filing year effects by applying dummy variables for the IPO years (*Y*), where (i) is indexing the years, i=1...,15. $\epsilon$ is the error term.

Table 7 - IPOs' Short-Run Performance By Different Firm types

| | Underpricing | |
|---|---|---|
| | (1) | (2) |
| Permanently Innovative | 0.113** | 0.111 |
| | (0.055) | (0.072) |
| Innovative Start-ups | 0.087 | 0.060 |
| | (0.097) | (0.105) |
| Facits | 0.017 | 0.013 |
| | (0.068) | (0.095) |
| Denoted within 5 years | | -0.005 |
| | | (0.099) |
| Top ranked underwriter | | -0.069 |
| | | (0.086) |
| Age of firm | | 0.000 |
| | | (0.001) |
| Constant | -0.086 | -0.093 |
| | (0.073) | (0.154) |
| Year of IPO dummies | No | Yes |
| Sector dummies | Yes | Yes |
| Observations | 333 | 225 |
| $R^2$ | 0.026 | 0.128 |

*Notes:* Underpricing of the firms undergoing an IPO in the chosen time period is the dependent variable in both regressions. The model is based on an OLS regression and displayed are the beta coefficients, and within parentheses are the robust standard errors. ** indicates that the coefficient is statistically significant at a 5% level.

The results presented in Table 7 show that the main finding of the regressions is that the *permanently innovative* firms have relatively high underpricing. This supports earlier research that found that innovative firms tend to be more underpriced (Chin et al., 2006). This means that investors were willing to pay more than the initial offering price when investing in these companies, indicating that they have a preference for innovative firms. Though not statistically significant, both *innovative start-ups* and *Facits* had positive coefficients with the former being stronger, although both are smaller than for the permanently innovative firms. Altogether, this implies that investors have some ability to predict future innovativeness and do not base their assumptions solely on the firm's prior patents.

Though not significant, *top ranked underwriter* imply a negative effect on underpricing, indicating that a renowned underwriter may be able to mitigate underpricing (c.f. Carter and Manaster, 1990; Brau and Fawcett, 2006; Chin et al., 2006) and contradicts research by Loughran and Ritter (2004) and Deb (2013). However, Table 8 shows that permanently innovative firms are the most likely among both the innovative and the non-innovative firms to have a top ranked underwriter. Looking at these firms, there seems to be a trade-off between the signalling value and investor confidence in well renowned underwriters and the expectations on future profitability of innovative activities. Alternatively, these results could imply that investor preferences for innovation may be underestimated even when the initial offering price is determined with the assistance of top ranked underwriters. Another possible explanation for the results is that the permanently innovative firms are the most likely to be willing to set a low initial offering price due to their confidence in their innovativeness, as argued by Guo, Lev and Shi (2006).

The weak coefficient for *age of firm* implies no impact on the level of underpricing, in contrast to results found by Ritter (1998). Similarly, whether the firm would end up being denoted from the market within five years of the IPO also implies close to no impact on the short-term performance and initial demand for the firms. Furthermore, it should be noted that these coefficients are not statistically significant. Considering that Table 8 shows that innovative start-ups and permanently innovative firms are less likely to be denoted than non-innovative firms and especially Facits, the results indicate that innovation does pay off in the long run and hence that the ability to identify firms that will stay innovative would benefit investors.

Table 8 - Descriptive Statistics Firm Specific Variables

| | Permanently innovative | Innovative start-ups | Facits | Non-innovative | Total |
|---|---|---|---|---|---|
| Well-renowned underwriter: | 25.00% | 4.55% | 6.90% | 16.85% | 16.88% |
| Denoted within 5 years after IPO: | 7.69% | 4.44% | 34.29% | 23.26% | 11.73% |
| Average age at year of IPO: | 11.56 | 9.49 | 12.51 | 9.36 | 10.47 |

*Notes:* Sample of 541 firms undergoing an IPO within the set time frame. The average age is set in years.

### *6.2 Signal-value of patents*

It has been suggested that at the time of an IPO, a firm may use their patents to signal to the market that they are innovative (Long, 2002; Chin et al., 2006; Guo, Lev and Shi, 2006; Deb, 2013; Zhou and Sadeghi, 2019). Table 9 shows that permanently innovative firms are the most likely to mention patents in their prospectus, but that Facits do this almost as much. There are no large differences between how likely the three groups are to advertise their patents in their prospectus, but innovative start-ups are the ones that do it the most. Furthermore, interestingly, innovative start-ups are far more likely to advertise their patents than to only mention them in their prospectus, compared to the other two groups. This is likely because innovative start-ups are more dependent on external funding for their innovation and therefore need to sell the value of their pending innovations to investors.

Table 9 - Descriptive Statistics Firm Specific Variables

| | Permanently innovative | Innovative start-ups | Facits | Total |
|---|---|---|---|---|
| Refers to patents in prospect: | 90.48% | 63.64% | 85.71% | 83.05% |
| Mentions patents in prospect: | 39.05% | 9.09% | 35.71% | 31.07% |
| Advertises patents in prospect: | 51.43% | 54.55% | 50.00% | 51.98% |

*Notes: Refers to patents* represents the percentage of firms that write about patents in their respective prospectuses. This category is then further divided into *Mentions patents* and *Advertises patents*. These two are mutually exclusive and divide the firms that only mention patents or patent applications in the prospectus and the ones that advertise the patents or patent applications.

To study the signalling value of patents we, similarly to above, used OLS regressions estimated with standard errors, and evaluated the effect of the same control variables. To get a clearer picture of whether patents have signalling value, we took into consideration how many of the firms with patents in our sample brought up patents and/or patent applications in their prospectus for their IPO. This was to determine whether patents worked as a signal to investors and had an effect on underpricing, since if patents can be used to signal value to investors, then information asymmetry should lessen which should mitigate underpricing. The baseline equations for the regressions can be seen below:

$$\text{Level of Underpricing} = \alpha + \beta_1 \text{PS} + \beta_2 \text{DF} + \beta_3 \text{UW} + \beta_4 \text{AF} + \gamma_i \text{Y}_i + \gamma_j \text{S}_j + \epsilon \tag{7}$$

$$\text{Level of Underpricing} = \alpha + \beta_1 \text{PM} + \beta_2 \text{PA} + \beta_3 \text{DF} + \beta_4 \text{UW} + \beta_5 \text{AF} + \gamma_i \text{Y}_i + \gamma_j \text{S}_j + \epsilon \tag{8}$$

Since it is easy in today's digital world to get information about firms and patents, we assume that it is possible for all investors to get information about whether a firm has patents prior to the IPO. Thus the dummy *signal* (*PS*) in regression (7) was used for all firms having patent applications prior to their IPO to see if it had any signalling value to have patent applications on the short-term performance of the firm. The dummy was given a value of 1 if the firm had

at least one patent application in one of the three years prior to the IPO. However, since it is possible that investors do not go beyond the prospectus to find information about the firms' patent activities, we also included a dummy for if the firm mentions their patents or patent applications in the prospectus (*PM*), and alternatively if they advertise their patents or patent applications in the prospectus (*PA*). Similarly to above regressions (*Y*) is a year dummy for the year of the IPO where (i) is indexing the years 2000-2015, i=1...,15 and (*S*) is the sector dummy variable, where (j) is indexing sectors, j=1...11.

Table 10 - IPOs' Short-Run Performance With Respect to Signaling Patenting Activities

| | Underpricing | |
|---|---|---|
| | (1) | (2) |
| Signal | 0.028 | |
| | (0.061) | |
| Patents mentioned | | 0.058 |
| | | (0.077) |
| Patents advertised | | 0.122* |
| | | (0.064) |
| Denoted within 5 years | -0.010 | -0.006 |
| | (0.086) | (0.090) |
| Top ranked underwriter | -0.046 | -0.048 |
| | (0.076) | (0.078) |
| Age of firm | 0.000 | 0.000 |
| | (0.002) | (0.002) |
| Constant | -0.073 | -0.109 |
| | (0.183) | (0.187) |
| Year of IPO dummies | Yes | Yes |
| Sector dummies | Yes | Yes |
| Observations | 223 | 221 |
| $R^2$ | 0.124 | 0.136 |

*Notes:* The dependent variable for both regressions is underpricing for the firms undergoing an IPO within the chosen time period. The model is based on an OLS regression and displayed are the beta coefficients of the independent variables, * indicates that the coefficient is statistically significant at a 10% level.

The most important result in Table 10 is that the advertisement of patents in the prospectus has a positive effect on IPO underpricing. This observation has a weak significance but does indicate that pushing the point in the prospectus that the firm is innovative increases investor demand and willingness to buy the stock for a price above the initial offering price. This implies that all investors may not look for patent information outside of the prospectus. This goes in line with Chin et al's (2006) and Useches' (2014) claim that information about innovation is important to include in the prospectus since this will raise the capital made from the IPO. However, the coefficient for *patents mentioned* is not significant, indicating that if the firm only mentions their patents but doesn't push the value of them, then the information about patents have less, or even no, effect on investor demand. Furthermore, the coefficient for *signal* is not significant either, and has the smallest coefficient of the three patent

variables. This implies a very weak positive or no relationship between using patents as a signal of value and underpricing, indicating that patents do not mitigate information asymmetry of innovativeness. This is contradictory to earlier research by Long (2002), Guo, Lev and Shi (2006) and Zhou and Sadeghi (2019). Had patents worked as a signal that the innovative activities in a company created value and thus mitigated the uncertainty and information asymmetry this should have raised the offering price of the IPO and therefore lowered the underpricing. The beta coefficients for the variables *Denoted within 5 year, Top ranked underwriter* and *Age of firm* are similar to Table 7, and are still not significant.

Nonetheless, our results thus indicate that despite the information asymmetry and uncertainty of innovative activities, investors do not avoid innovative firms. Rather, they appear to prefer innovative firms and channel funds towards them and away from non-innovative firms when the firms first go public.

### *6.3 Long-term performance*

To further investigate the ability of investors to select and channel funds to innovative firms, we also needed to know if investors could predict, at the time of the IPO, which firms would do well in the future. If the future of the IPO was correctly anticipated at the first day of trading, the long-term development of the stock price should follow the development of the stock market in general in the long run (Lehmann-Hasemeyer and Streb, 2016). We therefore studied the long-term performance by looking at the share price of the firms five years after the IPO. To get an understanding about the movement of the stock market, SIXRX was used as a benchmark index.

Table 11 - Descriptive Statistics Long-term Performance by Different Firm types

| | Development of share price | Development of share price adjusted against benchmark index |
|---|---|---|
| **Permanently Innovative** | | |
| Mean: | 102.26% | 51.30% |
| Median: | -8.91% | -53.23% |
| St. Dev: | 340.77% | 334.55% |
| Min: | -99.42% | -267.70% |
| Max: | 1931.01% | 1870.49% |
| Observations: | 90 | 90 |
| **Innovative Start-ups** | | |
| Mean: | 85.05% | 34.98% |
| Median: | -21.48& | -80.74% |
| St. Dev: | 336.94% | 331.08% |
| Min: | -98.59% | -154.47% |
| Max: | 1500.00% | 1410.16% |
| Observations: | 36 | 36 |
| **Facits** | | |
| Mean: | -34.53% | -77.72% |
| Median: | -70.59& | -110.16% |
| St. Dev: | 100.04% | 106.82% |
| Min: | -98.86% | -174.90% |
| Max: | 337.63% | 296.61% |
| Observations: | 19 | 19 |

*Notes:* The column *Development of share price* represents the development of the share price unadjusted for fluctuations on the stock market. *Development of share price adjusted against benchmark index* instead shows the development of share price five years after the IPO adjusted for changes on the stock market. The development of the stock market is represented by the benchmark index SIXRX.

Table 11 shows that amongst the permanently innovative firms and the innovative start-ups, there are large standard deviations implying large variation in the development of share price within both groups. Within these groups there is also a considerable difference between the means and the medians. The Facits show a negative long-term development and also have large, but comparably smaller standard deviation, implying a somewhat smaller variation in the development of the share prices for these firms. A possible explanation for this is the fact that the Facits do not have any patent applications in the years following the IPO. Innovation is risky and even after spending large amounts of resources on innovative activities there are no guarantees that it will lead to any breakthroughs or significant profits. The general decline

of successful patenting activities leading to patent applications might thus be the reason for the negative development of the share price, and also why Facits have a smaller standard deviation and more similar means and medians than the other two groups[10].

To get a clearer picture of the relation between long-term performance and innovation we conducted OLS regressions estimated with standard errors. The performance was adjusted for the development of the stock market throughout the same period using the benchmark index SIXRX and the baseline specifications of the regressions were:

$$\text{Adjusted long-term performance} = \alpha + \beta_1 \text{PI} + \beta_2 \text{StartUp} + \beta_3 \text{Facit} + \gamma_j \text{S}_j + \epsilon \tag{9}$$

$$\text{Adjusted long-term performance} = \alpha + \beta_1 \text{PI} + \beta_2 \text{StartUp} + \beta_3 \text{Facit} + \beta_4 \text{UW} + \beta_5 \text{AF} + \gamma_i \text{Y}_i + \gamma_j \text{S}_j + \epsilon \tag{10}$$

The variables are set after the same approach as for equations (5) and (6) and the results for the regressions are displayed in Table 12.

[10] By performing t-tests, we conclude that there is a statistically significant difference between the permanently innovative firms and the Facits on a 1% significance level both for the adjusted and unadjusted numbers. There is also a statistically significant difference between the innovative start-ups and the Facits, but on a 10% significance level for both the adjusted and unadjusted numbers. However, the t-tests do not show a statistically significant difference between the permanently innovative firms and the innovative start-ups. The results for the t-tests are shown in the appendix (Table A.3-A.8).

Table 12 - IPOs' Long-term Performance By Different Firm types

| | Adjusted long-term performance | |
|---|---|---|
| | (1) | (2) |
| Permanently Innovative | 0.683* | 0.234 |
| | (0.368) | (0.600) |
| Innovative Start-ups | 0.627 | -0.238 |
| | (0.487) | (0.716) |
| Facits | -0.576 | -1.124 |
| | (0.614) | (0.907) |
| Top ranked underwriter | | -0.030 |
| | | (0.597) |
| Age of firm | | -0.001 |
| | | (0.013) |
| Constant | 1.219 | 0.690 |
| | (0.709) | (1.242) |
| Year of IPO dummies | No | Yes |
| Sector dummies | Yes | Yes |
| Observations | 434 | 245 |
| $R^2$ | 0.041 | 0.109 |

*Notes:* The model is based on an OLS regression with the dependent variable as performance over the five consecutive years following the IPOs adjusted for the development of the stock market, represented by the benchmark index SIXRX. Displayed are the beta coefficients of the independent variables and in parentheses their respective standard errors. * indicates that the coefficient is statistically significant at a 10% level.

The main finding of Table 12 was that the *permanently innovative* firms shown in regression (1) perform better than the market, which contradicts research by Lehmann-Hasemeyer and Streb (2016) and Ritter (1998) who claimed that investors are usually overly optimistic about IPOs. In other words, investors appear to underestimate the long-term performance of the permanently innovative firms on their first day of trading. However, it should be noted that these results are at a weak significant level. By looking at the descriptive statistics in Table 11, it should also be taken into consideration that there might be a risk associated with investments in these firms due to the large standard deviations which indicates large variations in the performance of these firms. The great variations, in addition to the differences between the mean and median development of the permanently innovative firms, indicating that the long-term performance is skewed, could further explain why the stock

market would hesitate to invest in these firms, leading to their long-term performance being underestimated.

In our sample of innovative firms, the Facits have the lowest development of share price over the five consecutive years following an IPO, when looking at the descriptive statistics in Table 11. The same goes for the regressions in Table 12, but the coefficients for the variable are not significant. This implies that for Facits, where the level of innovation declines after the company goes public, investors tend to overestimate the performance of these firms at the first day of trading. The results for the *innovative start-ups* in Table 12 are not significant either, but they show both large differences between coefficients in regression (1) and (2), and large standard deviations in Table 11. The reason for this might be that since innovative start-ups had no patent applications prior to the IPO, their innovativeness was untested and more uncertain. As such, investors might anticipate the risk of investing in innovative start-ups as larger.

Taking the results for the three groups together, rather than contradicting previous research that found that innovative firms out-perform other IPO firms in the long-run (Chin et al., 2006), our results imply a more complex picture of the long-run development of innovative firms.

### *6.4 Overall stock performance*

The high initial demand for innovative firms indicates that the stock market is a good source of funding, from the perspective of innovative firms. Relating the fact that permanently innovative firms in comparison performed the best long-term to the results about short-term performance, we see that investors' initial preferences for permanently innovative firms are justified by a comparably higher long-term performance compared to non-innovative firms and Facits. This further shows that investors do have some ability to predict future innovativeness. These predictions do not seem to be based solely on past patenting, since patents do not seem to work as a signal of value to raise the offering price and lower underpricing. Advertising patents in the prospectus is however shown to raise investor demand. However, permanently innovative firms are shown to generally perform better than the market long-term, indicating that they tend to be underestimated at the first trading day, likely owing to the risk and the difficulty in evaluating innovation.

## 7. Conclusion

This paper found evidence that the funding gained from an IPO takes about five years to result in a rise in innovation, but that it does mitigate liquidity restraints and promote innovation in the long run. By comparing the level of innovation in firms undergoing an IPO with innovative firms deciding to remain private, we drew the conclusion that innovation is positively affected by the decision to go public. Hence, contradicted by earlier research which found that going public causes information asymmetry which ultimately impedes innovation (Long, 2002; Mizik, 2010; Wies and Moorman, 2015), our results showed that turning to the stock market for funding could be seen to boost innovation.

By dividing the innovative firms into different groups depending on their nature of innovative activities, this paper gave a complex picture of the stock exchange as a market for innovation. In support of earlier research we also found that innovative firms prefer the stock market as a source of funding (Casson, Martin and Nisar, 2008; Lee, Sameen and Cowling, 2015), despite experiencing a higher level of underpricing (Chin *et al.*, 2006; Guo, Lev and Shi, 2006; Zhou and Sadeghi, 2019). Firms with more consistent and long-lived innovativeness were shown to experience a higher initial demand compared to less innovative firms and firms that did not stay innovative in the long run. This indicates that investors have some ability to predict future innovativeness and do not base their assumptions solely on the firm's prior patents. As such, patents do not work as a signal and do not mitigate information asymmetry, contradicting earlier research by Long (2002), Guo, Lev and Shi (2006) and Zhou and Sadeghi (2019). However, investors were shown to pay attention to the information in the IPO prospectuses and thus the use of patents as a selling point in the prospectus can raise investor demand for an IPO.

There was a large variation in the performance of innovative firms. This could make investors hesitant, and might be one of the reasons that investors had difficulties in predicting the future performance of innovative firms. Generally, the long-term performance of firms that stayed innovative in the years following an IPO were underestimated on the first day of trading, while the firms whose innovativeness declined in the long run, tended to be overestimated. This means that firms with persistent innovation tended to lose out on money from the IPO. However, investors still showed preference for innovative firms and funding was channelled towards innovative firms and was used by firms as a source of funding to stay innovative and to promote innovation in the long run.

### *7.1 Implications*

The study is of value for both parts of the stock market; the companies and the investors. Not least might the results be valuable for innovative entrepreneurs that are facing the decision of whether to go public or not. By giving insights into the effects of going public on innovation and investors' preferences towards innovative firms, the study might act as a guide in the decision of optimal capital structure for promoting and staying innovative. Among other implications, it advises firms writing a prospectus for an IPO to advertise information about patents and patent applications in order to increase demand among investors.

From an investor's perspective the study gives important insights into the performance and characteristics of innovative companies and cues about where investments should be placed in order to promote both long-term innovativeness and firm performance.

### *7.2 Limitations and future research*

We use two different control groups in this paper, both which have limitations. Both control groups consist of private firms to control for how much innovation firms could have achieved without going public. The first control group consisted of withdrawn IPOs. Since firms may decide to go public as a stage in their corporate life cycle, our results may include life cycle effects in addition to the effects of the IPO on innovation (Bernstein, 2015). Using withdrawn IPOs as a control group should aid in overcoming this bias. However, to our knowledge there exists no complete database of withdrawn Swedish IPOs, leaving us with a very small sample. To make up for this we include the second control group, consisting of private firms. Both control groups were then matched to the firms with patents undergoing an IPO in our sample through a *nearest neighbour approach*. However, with this approach a large number of potentially important observations may be discarded (Stuart, 2010). Furthermore, the matching is limited to three criteria, meaning that several other factors potentially affecting the level of innovation may not be controlled for. We use both control groups to alleviate the limitations with each, but it would have been beneficial if a large sized and matched sample of withdrawn IPOs, and/or a more furrow matching approach of private firms, could have been used.

Patenting is a way to protect the results of innovation, however there are shortcomings in assuming that patent applications fully reflect the level of innovation within firms. Innovating activities might show not only thorough patenting, but also in, for example,

R&D-expenditures. Suggestions for future research might thus be to take into consideration not only one measure for innovation, but to also look at R&D-expenditures, and to take into consideration a wider value measurement of patents, such as granted and scaled patents, originality and generality etc. (c.f. Bernstein, 2015; Wies and Moorman, 2015; Lee, 2020).

Furthermore, the size of our sample might also be a limitation to the study. The Swedish stock market is a relatively small market and thus there are a limited number of firms undergoing an IPO within our time period, and an even smaller number of these firms having patents within our set time frames. With an even greater sample of firms, the results might have been more statistically significant. Another suggestion for future research is hence to look at either a larger time period or at a greater stock market with more IPOs within the set time frame.

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# Appendix

Table A.1: Variable Definitions - Innovation

| ***Innovation*** | **Variabel** | **Definition** |
|---|---|---|
| | IPO-3 | The year 3 years before the IPO |
| | IPO-2 | The year 2 years before the IPO |
| | IPO-1 | The year 1 year before the IPO |
| | IPO+1 | The year 1 year after the IPO |
| | IPO+2 | The year 2 years after the IPO |
| | IPO+3 | The year 3 years after the IPO |
| | IPO+4 | The year 4 years after the IPO |
| | IPO+5 | The year 5 years after the IPO |
| | LnAssets | Logarithm of total assets at the time of the IPO filing |
| | GP | Going Public, value of 1 for firms the year of the IPO and the years after |
| | GPxY | Going Public x year, interactive variable that divides patent applications after an IPO between the years after the IPO |
| | IPO | Firms that go public, value of 1 for firms that go public during the sample period |
| | Year | Year effects for the period in the sample |
| | IPOxYear | Difference in patent application between private and public firms over sample period |

Table A.2: Variable Definitions - Performance

| ***Performance*** | **Variabel** | **Definition** |
|---|---|---|
| | Level of Underpricing | Underpricing, closing price of first trading day minus offering price, divided by offering price |
| | StartUp | Innovative start-ups, firms with patents only after the IPO |
| | PI | Permanently innovative, firms with patents both before and after the IPO |
| | Facit | Firms with patents only before the IPO |
| | DF | Denoted within 5 years, value of 1 for firms that were denoted from the market within 5 years after the IPO |
| | AF | Age of firm, number of years since the firm was started at the time of the IPO |
| | UW | Top ranked underwriter, value of 1 for firms with a main underwriter for their IPO prospectus that was given a top ranking |
| | Y | Year, IPO filing year effects |
| | S | Sector, sector effects |
| | PS | Signal, value of 1 for firms with patents within 3 years before the IPO |
| | PM | Patents mentioned, value of 1 for firms that mention their paten(s) or patent application(s) in their prospectus |
| | PA | Patents advertised, value of 1 for firms that advertise their patent(s) or patent application(s) in their prospectus |
| | Long term performance | Development of share price across 5 years after the IPO |
| | Adjusted long term performance | Development of share price across 5 years after the IPO, adjusted against benchmark index |

**Unadjusted Long-term Performance: Student's T-test**

Table A.3 - Student's t-test: Permanently Innovative & Innovative Start-ups

| | Permanently Innovative | Innovative Start-up |
|---|---|---|
| Mean: | 1.0226 | 0.8505 |
| Variance: | 11.6125 | 11.3528 |
| d.f: | 124 | |
| t-value: | 0.2569 | |
| P-value: | 0.7977 | |

*Notes:* The table shows a two-sided student's t-test for unadjusted long-term performance for Permanently firms and Innovative start-ups. The test is based on two samples assuming equal variances.

Table A.4 - Student's t-test: Innovative Start-ups & Facits

| | Innovative Start-up | Facit |
|---|---|---|
| Mean: | 0.8505 | -0.3453 |
| Variance: | 11.3528 | 1.0008 |
| d.f: | 45 | |
| t-value: | 1.9712 | |
| P-value: | 0.0548 | |

*Notes:* The table shows a two-sided student's t-test for unadjusted long-term performance for Innovative start-ups and Facits. The test is based on two samples assuming unequal variances.

Table A.5 - Student's t-test: Permanently Innovative & Facits

| | Permanently Innovative | Facit |
|---|---|---|
| Mean: | 1.0226 | -0.3453 |
| Variance: | 11.6125 | 1.0008 |
| d.f: | 97 | |
| t-value: | 3.2092 | |
| P-value: | 0.0018 | |

*Notes:* The table shows a two-sided student's t-test for unadjusted long-term performance forPermanently innovative firms and Facits. The test is based on two samples assuming unequal variances.

**Adjusted Long-term Performance: Student's T-test**

Table A.6 - Student's t-test: Permanently Innovative & Innovative Start-ups

| | Permanently Innovative | Innovative Start-up |
|---|---|---|
| Mean: | 0.5130 | 0.3498 |
| Variance: | 11.1924 | 10.9614 |
| d.f: | 124 | |
| t-value: | 0.2481 | |
| P-value: | 0.8044 | |

*Notes.* The table shows a two-sided student's t-test for long-term performance adjusted against benchmark index SIXRX representing the development of the Swedish stock market for Permanently firms and Innovative start-ups. The test is based on two samples assuming equal variances.

Table A.7 - Student's t-test: Innovative Start-ups & Facits

| | Innovative Start-up | Facit |
|---|---|---|
| Mean: | 0.3498 | -0.7772 |
| Variance: | 10.9614 | 1.1411 |
| d.f: | 47 | |
| t-value: | 1.8665 | |
| P-value: | 0.0682 | |

*Notes:* The table shows a two-sided student's t-test for long-term performance adjusted against benchmark index SIXRX representing the development of the Swedish stock market for Innovative start-ups and Facits. The test is based on two samples assuming unequal variances.

Table A.8 - Student's t-test: Permanently Innovative & Facits

| | Permanently Innovative | Facit |
|---|---|---|
| Mean: | 0.5130 | -0.7772 |
| Variance: | 11.1924 | 1.1411 |
| d.f: | 91 | |
| t-value: | 3.0044 | |
| P-value: | 0.0034 | |

*Notes:* The table shows a two-sided student's t-test for long-term performance adjusted against benchmark index SIXRX representing the development of the Swedish stock market for Permanently firms and Facits. The test is based on two samples assuming unequal variances.

**Grubbs Test**

Table A.9 - Grubb's Test - Long-term performance

| | Case number | Absolute Z-score |
|---|---|---|
| **Highest** | | |
| | 119 | 10.17 |
| | 135 | 3.04 |
| | 102 | 2.26 |
| | 141 | 2.25 |
| | 125 | 2.17 |
| **Lowest** | | |
| | 177 | 0.02 |
| | 152 | 0.03 |
| | 190 | 0.04 |
| | 15 | 0.05 |
| | 159 | 0.05 |

*Notes:* The table shows data for performing a Grubbs' test, also known as the maximum normalized residual value, to detect outliers. The case numbers represent the index for firms in our sample, and displayed are also the absolute Z-scores for respective firms. There were a total of 146 observations in the sample. The Grubbs' critical value at an upper 0.1% significance level for 146 observations is 4.216, and at a 10% significance level it is 3.142. Hence, the observation with the case number 119 was removed, while all other observations were left in the sample.