Underpricing of Initial Public Offerings

- Evidence from the Oslo Stock Exchange -

Master thesis

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Abstract

In this thesis we investigate the abnormal first-day return of 88 initial public offerings in Norway from 2005 to 2015. The majority of previous studies of IPO underpricing are directed towards larger stock markets, and only a limited number of research papers have examined the phenomenon in a smaller economy such as Norway. Thus, we attempt to explain the underpricing of Norwegian IPOs by using a selection of existing theories from the vast IPO literature.

We find an average market-adjusted underpricing of 2.87 percent, which is slightly lower than the underpricing observed in previous studies in Norway. However, the low estimate is in line with the trend of decreasing initial returns, and the finding is statistically significant at the 1 percent level. After controlling for firm and issue specific characteristics, as well as year- and industry effects, we find evidence in support of Hanley's (1993) partial adjustment theory. That is, it appears that Norwegian underwriters do not fully adjust the offer price to reflect information obtained in the period prior to the IPO, which can explain parts of the abnormal first-day returns. Our results contribute to the IPO literature with two implications for potential investors. First, if the return of the Oslo Børs All-Share Index is increasing in the months prior to an IPO, the investors can expect to realize a higher initial return, on average. Second, if the share price is revised above the midpoint of the indicative file price range, the investors can assume that the IPO will be subject to higher underpricing.

Contrarily, we find that the choice of pricing mechanism (book-building or fixed-price), and hiring a prestigious investment bank to underwrite the offering have no significant effect on the level of underpricing. Moreover, the volatility prior to an IPO is not related to the level of initial return, and going public in a "hot issue" market is not associated with more underpricing than going public in a "cold" or "neutral" period. Consequently, as the majority of our selected theories do not seem to be significant in explaining the underpricing of Norwegian IPOs, there is room for further research within this market.

We want to thank our supervisor, Christian Rix-Nielsen, who has provided us with insightful guidance, inspiration, suggestions and constructive feedback throughout the process of writing this thesis. In addition, we would like to thank the team at the Oslo Stock Exchange for kindly providing us with the IPO sample and other relevant data that has been necessary in order to test the selected theories of underpricing.

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1. Introduction

In the first part, we will introduce the background and present the problem statement of our thesis. Subsequently, we will disclose the delimitations of our research paper and provide the outline of the thesis.

1.1. Background

One assumption that underpins the financial markets is the efficient market hypothesis. This theory claims that investors should not be able to acquire abnormal returns in capital markets, as all public information is incorporated into the stock price. However, academics have discovered that an area that violates the efficient market hypothesis is initial public offerings (IPOs). An IPO is a process by which a private company becomes listed on a stock exchange and sells a share of its stock to the public for the first time. Previous researchers have observed that firms going through the process of becoming publicly traded often face an issue of being undervalued. On average, the issue shares are sold at a discount relative to the price at which they subsequently trade for in the market. This phenomenon is referred to as underpricing, and the ones that seem to benefit from this anomaly are mainly the investors who subscribed to shares in the offering. These investors can sell their shares in the after-market and collect an abnormal return, on average. Moreover, the investment banks that underwrite the IPOs (commonly referred to as the underwriters) benefit from underpricing because it allows them to control their risk. On the contrary, the pre-IPO shareholders of the issuing firm appear to be the ones hurt by the underpricing because they could have sold their shares at a higher price in the after-market.

The fact that issuers are willing to "leave money on the table" has puzzled academics for decades, and the phenomenon has been documented all around the world. As a result, studies aiming to explain the reason of underpricing dates back to the 1970s, and numerous theories have been put forward in order to solve the puzzle. Several theories have proven significant in explaining parts of the observed underpricing; however, no theory has been able to fully explain the level of underpricing.

Although some studies have documented the existence of underpricing in Norwegian IPOs, there are still many theories that have not yet been tested in the Norwegian market. Furthermore, no study has used a sample including IPOs after 2008 (to our knowledge). The lack of empirical studies of Norwegian IPO underpricing may be due to the fact that few firms go public each year, which leads to a small data sample. Alternatively, it could be explained by a low interest among foreign academics. Thus, the objective of our thesis is to investigate if a selection of the most supported theories from the existing IPO literature is useful in explaining the observed underpricing in Norwegian IPOs. We will use a unique and updated dataset including initial public offerings

between 2005 and 2015. This time period enables us to study the level of underpricing under different economic conditions, as our sample includes both pre- and post-financial crisis IPOs.

1.2. Problem statement

Many of the theories and empirical studies of underpricing are directed towards bigger and more developed economies, like the U.S. Hence, if smaller economies face the same issue where stocks are not priced at their fair market value; are the existing theories able to explain the level of underpricing in a smaller economy such as Norway? This forms the basis of our problem statement, which can be expressed as:

"Can a selection of theories that has proven to be significant in explaining reasons for underpricing internationally also explain the underpricing of Norwegian IPOs?"

In order to answer this problem statement, we have constructed six hypotheses motivated by existing theories of underpricing from the IPO literature. The theories that have proven to be the most successful in explaining the reasons for underpricing worldwide are based on asymmetric information between the parties involved in the IPO process. Moreover, many studies find support in favor of ex-ante risk factors having an impact on the level of the initial IPO return. Therefore, we select six hypotheses that aim to explain the average underpricing of Norwegian IPOs using theories of risk compensation and asymmetric information. The conclusion of our hypotheses will have implications for investors who are considering investing in Norwegian IPOs. We hope to identify a pattern of initial returns that potential investors can use to select the IPOs that should be associated with abnormal first-day returns.

Our findings contribute to the academia in several ways. Firstly, we investigate underpricing in a market that has received little attention in the IPO literature using an updated and unique data sample, thereby providing an estimate of the average underpricing in Norway that is up to date. Second, most of our selected theories have not yet been studied among Norwegian IPOs (to our knowledge), thus both supporting and rejecting existing theories will provide useful information to the literature. Finding evidence in favor of a theory will confirm that at least a part of the underpricing of Norwegian IPOs can be explained by existing theories, whereas finding evidence against a theory would suggest that this theory is not applicable in a smaller economy like Norway.

The hypotheses are presented in section 3.2.

1.3. Delimitations

Due to limited data availability and time constraint, it has been necessary to limit the scope of our research. Our empirical study will only address the Norwegian market, which means that our findings may only be applicable in explaining underpricing of Norwegian IPOs and smaller stock

markets in general. The Oslo Stock Exchange (from now on referred to as OSE), is selected as our research objective because it has received little attention in previous research. Moreover, it is the stock exchange in our country of origin, thus it is the market we find most interesting and in which we hold the greatest knowledge.

It is possible to go public on two different exchanges of OSE; the main list, Oslo Børs (here after referred to as OB), and Oslo Axess. IPOs on Oslo Axess have been excluded due to the small size and illiquidity of stocks on this exchange. Including these IPOs may cause bias in our calculation of the average initial return due to the large bid-ask spread.

Underpricing has been the objective of many research papers, and as a consequence, a vast amount of underpricing theories have been developed. However, time constraints and data availability has also made it necessary to restrict the number of theories to be tested. Some of the theories require confidential data, hence, these theories have not been considered. Further, some of the theories have received little and/or weak support by previous researchers and are found to be less credible. Finally, from the theories that have received empirical support and are possible to test using the available data, our final selection is based on the theories' relevance for the Norwegian stock market in terms of properties of the economy, as well as our own interest.

2005 has been chosen as the start year of our sample. Including earlier years might have led to the exclusion of many firms due to missing information, which in turn could have introduced survivorship bias in our sample. Additionally, by excluding older IPOs, our sample and thus evidence is more "up to date". Further, the time frame of 11 years is considered to be a representable time period as we should able to capture both "hot" and "cold" periods.

Lastly, we only focus on the short-term performance (first-day returns) of IPOs, and do not attempt to explain long-term performance of initial public offerings in Norway.

1.4. Outline

Our thesis is organized in five sections (including introduction). In section 2, we provide an overview of the Norwegian stock market and review the process of going public. Further, selected theories from the IPO underpricing literature are presented and the most relevant theories are explained in detail. Subsequently, the methodology in section 3 covers the research objectives of our thesis and how we proceed to test the hypotheses. This involves the data selection process and how the data has been applied to construct the appropriate variables. Section 4 presents our regression analysis and compares our results to previous empirical research. Additionally, we provide a detailed explanation of which hypotheses that are supported in the Norwegian stock market, as well as an overview of econometric issues that may be present in our empirical findings, and how we solve these problems. Finally, a conclusion of our thesis is presented in section 5.

2. Theory

This section will provide some general information about initial public offerings and the Norwegian IPO process. Further, we will discuss one of the IPOs puzzles; underpricing, and look into earlier research and different theoretical aspects of underpricing which forms the basis of our empirical research in this paper.

2.1. Initial public offering (IPO)

An initial public offering (IPO) is a process where a privately held firm goes public for the first time by offering a fraction of shares to third-party investors through a stock exchange, thereby gaining access to the public capital market. The stock market listing leads to a change in the ownership of the firm as the firm will be publicly traded and thus owned by public stockholders instead of being operated and owned by private investors, such as the entrepreneurs (Reference for Business 2016). The dispersed ownership creates post-IPO liquidity, which is an advantage for the shareholders and the firm.

The decision to go public may be the most important and challenging decision a company's board of directors will make during the firm's operating life, and there are many reasons why companies decide to be listed on a stock exchange. However, the most common reasons are to raise additional equity capital or to sell down stakes in the company. In addition, being listed on an organized platform makes trading with potential investors easier.

Publicly traded firms offer two type of shares to investors; primary shares and secondary shares. Primary shares, known as newly issued common stock, are new shares that are offered at a primary offering in order to raise additional capital, while secondary shares, known as existing shares, are stakes issued by pre-IPO owners through secondary market trading, enabling them to exit or reduce their ownership in the firm without raising any fresh equity. How and at what price the shares will be sold, referred to as the offer price, depends on the financial advisor (the underwriter), and what kind of mechanism the underwriter will use in order to sell the company's shares (Berk & DeMarzo 2014, 813).

2.1.1. The players

The main parties involved in a Norwegian IPO are the issuing firm, the investment bank (underwriter) and the investors. Each player's primary responsibilities and objectives are briefly introduced below.

The issuer

The "issuer" refers to the company that is being listed on the stock exchange. A successful issuance requires a lot of preparation in advance, such as to identify and coordinate a team of players that

will be responsible for the listing process. The issuing firm needs to hire experts and select staff members that will be involved in the listing process, while at the same time managing the internal team through the daily operations to ensure a smooth day-to-day operation.

The primary responsibilities of the issuer are related to the registration process, and involve contact with the Oslo Stock Exchange and providing necessary information for the investment bank to prepare the registration statement (PricewaterhouseCoopers 2011). Generally, the objectives of the issuer are to maximize the proceeds from the offering, obtain a wider distribution of ownership, and to create a secondary market for its shares.

The investors

In the financial market, one can divide investors into two groups based on the size and objective of their investments. The two investor types are referred to as retail and institutional investors. Retail investors are typically individual investors buying small amounts of shares, and the share price is not significantly affected by the individual purchases of this group. Institutional investors include banks, mutual funds, pension funds etc., who often trade in larger blocks of shares. Thus, their purchasing decisions can significantly influence the share price (InvestorGuide 2016).

Furthermore, one can distinguish between informed and uninformed investors (Berk & DeMarzo 2014, 440). In relation to IPOs, we refer to retail investors as uninformed, while institutional investors are assumed to be informed. According to Rock (1986), institutional investors are key players in the pricing and allocation of IPO shares due to their informational advantage. The private information held by informed investors can be used to correctly price the offer shares, and during book-building, the underwriter attempts to induce the investors to reveal this information truthfully. Lastly, both types of investors have aligned goals, which are to maximize future profits while being diversified and minimizing total risk (BlauStein Lawyers 2016).

The underwriter

The underwriter is the investment bank that conducts the offering on behalf of the issuing firm. The underwriter has experience from previous IPOs and can offer advice throughout the process. Moreover, the investment bank possesses information about general market conditions and different types of investors. Thus, the majority of issuers hire an investment bank to ensure effective marketing and support in the process of going public. The choice of underwriter is based on the goals of the issuer, the industry, and at which stage of the life cycle the firm is in.

The main responsibilities of the underwriter are to assist in the preparation of the registration document, perform business due diligence, conduct pricing and marketing of the offer shares and provide after-market support. The business due diligence consists of making sure the information in the registration statement is true, and that the document complies with legal requirements. The

pricing of the shares can be done by book-building or fixed-price, however, this will be more thoroughly discussed below. The after-market support consists of price stabilization and increasing the liquidity of the shares in the secondary market, which is beneficial both for the issuer and the investors.

There are commonly two types of deals the underwriter can make with the issuer; firm commitment and best effort deals. In a firm commitment IPO, the underwriter purchases the entire issue from the firm (usually at a discount) and resells it to the public. Thus, the underwriter bears all the risk, and the compensation he receives equals the spread between the price at which the underwriter bought the shares from the issuer, and the price at which they are resold to the public. In a best effort IPO, the underwriter does not buy any of the shares, but guarantees to use its best efforts to sell them. Such deals often have an all-or-non clause, so that the firm only goes through with the offering if all of the shares are sold. In this type of offering, the underwriter is compensated with a flat fee. Consequently, the underwriter stands to make more money from a successful firm commitment IPO than a best effort deal.

Lastly, the underwriter agreement may include an over-allotment option which allows the underwriter to issue additional shares (usually up to 15 percent of original size) at the offer price. This mechanism reduces the underwriter's exposure to losses, and can be used to smooth out price fluctuations in the after-market (Berk & DeMarzo 2014, 813-814; 819).

2.1.2. The pricing mechanisms

The two pricing mechanisms used to price Norwegian IPO shares are book-building and fixed-price, and the approaches differ in terms of how and at what stage in the IPO process the price is set. Book-building is known as a price discovery mechanism (Rawani 2009), where underwriters collect non-binding bids from potential investors during road shows. The bids are based on an initial price range provided by the underwriter and the issuer. The main purpose of the pre-offer marketing effort is to create interest for the IPO and to assess the aggregate demand for the shares, which further forms the basis for the offer price set by the underwriter. Contrarily, under fixed-price, the offer price is determined in advance of the IPO. Investors wanting to partake in a fixed-price offering must subscribe to shares at the full price, and the aggregate demand is first known when the issue is closed (Benveniste and Busaba 1997).

Consequently, in book-building the investors' demand for shares is known on a daily basis, while demand is only known at the end of a fixed-price offering. The U.S. book-building method has become increasingly popular in Europe over the past decade, and about 80 percent of the IPOs in Norway between 2005 and 2015 used this pricing mechanism.

2.1.3. The IPO process

How time consuming and comprehensive an IPO process is depends on the surroundings, the capability of the issuer, and the manager's knowledge about the public offering process (Espinasse 2011, 79). Norwegian firms use between 4 and 12 months to implement the IPO process, where the formal listing at the Oslo Stock Exchange takes minimum 4 weeks, depending on whether the firm chooses the ordinary listing process, the flexible listing process or the fast-track listing process. According to PwC (2014), Norwegian companies go through the following four steps to become publicly listed.

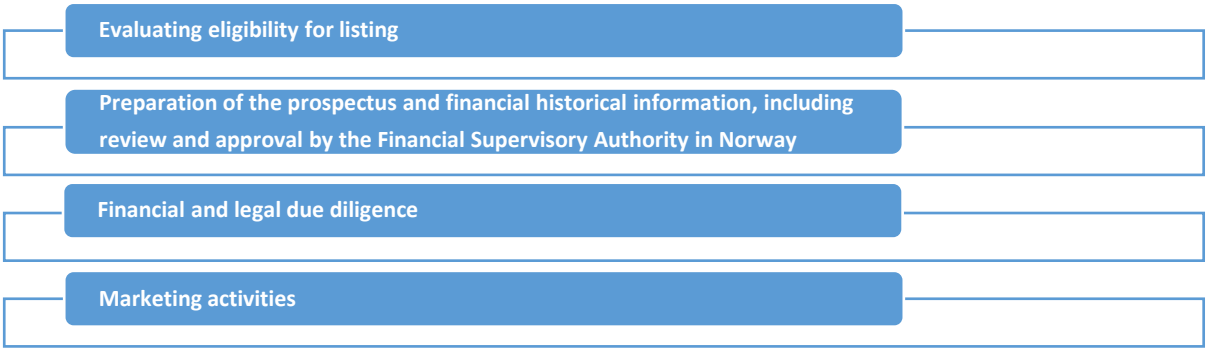

Figure 1: The process of going public in Norway.

The initial step of the process is to hire an investment bank. The issuer may hire several underwriters but usually selects one that will have the main responsibility for the offering (the lead underwriter) (Berk & DeMarzo 2014, 815). Subsequently, a preliminary meeting with all the parties involved in the offering is held. Here they discuss the purpose of the IPO, prepare the timeline, and allocate areas of responsibilities. Similar meetings are held throughout the process to solve problems that may arise, go through outlines of the prospectus and to monitor that the process is on schedule. The offering is publicly announced when the firm has submitted the listing application.

Step 1: Evaluating eligibility for listing: An initial meeting is held where the management and the underwriter meet a group from the Oslo Stock Exchange that will monitor the offering process and make sure that the company fulfills the regulatory requirements for the listing. To fulfil the requirements for listing on OB, the firm needs to provide a listing prospectus, have at least three years of operating history (dispensations can be granted), have a market capitalization of at least MNOK 300 and at least 500 shareholders, each holding shares with value of NOK 10.000. Moreover, the share price has to be minimum NOK 10, and at least 25 percent of the shares must be distributed among the general public (Oslo Børs 2016a).

Step 2: Preparation of the prospectus and historical financial information: The second step is to prepare the prospectus in accordance with the rules set by EU. The prospectus contains

information such as the planned use of the IPO proceeds, the risks associated with the business, the firm's payout policy and financial statements for the last three years. The finished prospectus is shared with the general public to ensure that all potential investors are equally informed about the firm's prospects. The prospectus is generally reviewed by the Financial Supervisory Authority of Norway before the publication.

Step 3: Financial and legal due diligence: A team composed of independent lawyers and auditors (including the underwriters) performs the financial and legal due diligence of the firm. The team's duties include site visits, being part of meetings between the board of directors and the shareholders, and reviewing the management, financial statements and tax returns. The due diligence procedures are submitted to the Oslo Stock Exchange before the listing application is handed in. If the independent lawyers and auditors point out any issues about the process, corrections have to be made or the firm has to inform the investors about the issues in the prospectus.

Step 4: Marketing activities, roadshow and investors: The fourth step is the promotion of the IPO, and this stage is critical in order to create demand for the shares. The underwriters arrange information gatherings, known as "road shows", across the country for financial analysts, brokers and potential institutional investors in order to create interest for the IPO and to assess the demand for shares. Throughout these meetings, the management has the ability to influence the investors beyond that of the prospectus (PricewaterhouseCoopers 2014).

2.1.4. Why go public?

The primary reasons why firms go public are to get access to the public capital market and to achieve a diversified ownership. The aim to raise additional capital is typically motivated by a desire to grow and develop the existing business idea, or to pay dividends to current shareholders (Taulli 2012). Publicly traded firms have access to a larger pool of cheaper capital (through the market of both domestic and foreign investors) compared to the privately held firms that usually only have access to the banking system. The lower overall cost of capital gives the publicly traded firms bargaining power when negotiating interest rates with banks (Colgate 2016). Moreover, the risk associated with the firm can be spread among a larger group of shareholders, allowing the private equity investors to diversify. Being publicly traded also increases the liquidity of the shares, enabling the shareholders to easily purchase or divest their shares (Oslo Børs 2016b).

According to Brealey, Myers and Allen (2011), there are several other advantages of being listed at a stock exchange; however, we mention a few. Firstly, public firms are able to raise additional capital in subsequent offerings. Further, the firms can put in place a stock option program that links the performance of the stock to the compensation of managers. Stock options can attract competent managers and align the incentive of management and investors, thereby reducing agency costs.

Lastly, listed firms are subject to more strict regulations than privately held firms, which consequently ensure more credibility and a better reputation of publicly traded companies. This is further making investors more confident to invest in listed entities (Taulli 2012).

However, there are also some disadvantages related to being listed. The process of going public is time consuming and expensive as it involves hiring a team of experts to assist in the process. Further, dispersed ownership and stricter regulations can also be seen as disadvantages. First, the management loses (some) control over the company and needs to make decisions based on the interest of a larger group of shareholders. Secondly, the stricter regulations that apply to a public entity involve publications of quarterly and yearly financial reports, and an increased liability to maximize the wealth of the shareholders. Thus, by going public the firm loses some of its private rights and it forces the management to run the business differently (Masters 2016).

2.1.5. The Oslo Stock Exchange

OSE is the only regulated market that offers securities trading in Norway. Both national and international firms are listed on the exchange, and due to the unique position in the sectors energy, shipping and seafood, OSE has received international recognition (Oslo Børs 2016c).

OSE offers trading of shares, bonds, equity certificates and fixed income products such as derivatives, exchange traded funds, and exchange traded notes and warrants (Oslo Børs 2016d). The exchange can be divided into five marketplaces: OB, Oslo Axess, Merkur Market, Oslo Connect and Nordic ABM, where OB and Oslo Axess are the only fully regulated markets. OB has the strictest requirements for listing (mentioned under step 1 of the listing process), and this marketplace consists of the larger and more established firms in Norway. This includes the firms in OBX, which is the benchmark index comprised of the 25 most liquid assets at OSE (Oslo Børs 2013).

Oslo Axess has less strict requirements and is therefore well suited for small- and medium sized firms having less than three years of financial records. Despite less strict requirements, the entities on Axess benefit from many of the same advantages of being listed on the main list (Oslo Børs 2016e). Nordic ABM is not subject to the regulations set by the Exchange Act, and is according to the Markets in Financial Instruments Directive an unregulated market offering interest-bearing instruments (Oslo Børs 2016f). Oslo Connect is a regulated marketplace offering OTC derivatives, which are non-standardized derivatives that are not listed on the stock exchange (Oslo Børs 2016g). Lastly, Merkur Market is suitable for all sized firms with the main desire to gain access to the public capital market through trading in bonds and equity certificates. This market appeals mainly to the firms that are not able to comply with the listing requirements of OB or Oslo Axess, or those that do not want to be fully listed on an exchange (Oslo Børs 2016h).

The industries

OSE is divided into industry indices based on the Global Industry Classification Standard (GICS). Below, we have illustrated the contribution of each industry (measured by the total market capitalization of the firms currently included in the index) to the OSE. In addition, the industry distribution of our IPO sample is included for comparison.

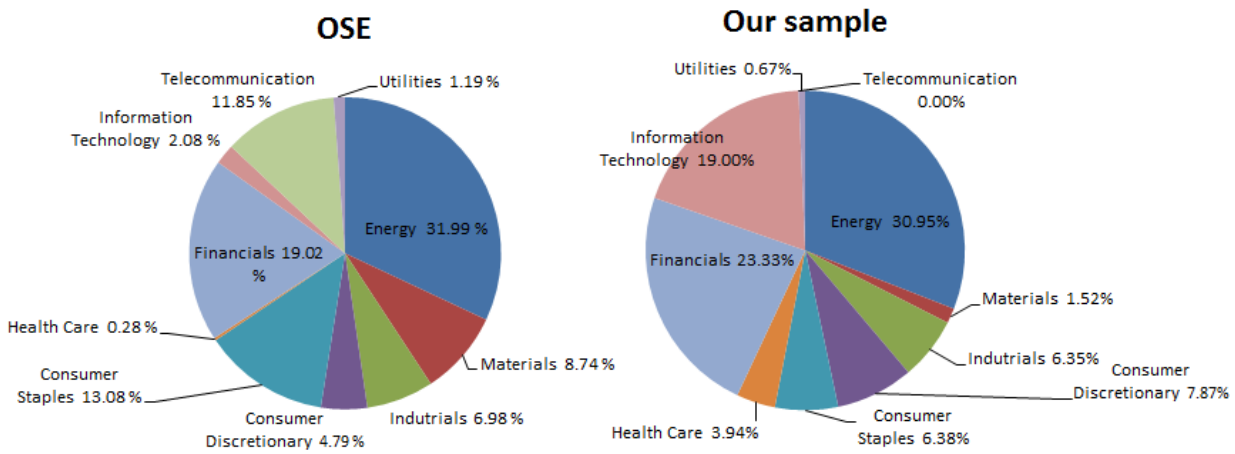

Figure 2: The industry division based on GICS classification on the OSE (left) per. 30.05.16, and in our sample of IPOs between 2005 and 2015 (right). The shares are weighted by market capitalization. Source: Adapted from Oslo Børs (2016i).

On the OSE, we observe that energy is the largest sector, with a weight of 32 percent. This is not surprising considering that Norway is an international leader in the oil industry, and the energy contribution in our IPO sample closely matches the weight in the OSE. The second largest industry at OSE is financials, with a share of 19 percent, which also is the case for our sample. Further, telecommunications, consumer staples and materials have weights around 10 percent, while industrials, consumer discretionary, IT, utilities and health care contribute with approximately 15 percent of the value altogether. When we compare our sample to the OSE, the largest deviations are found in telecommunications and information technology. The lack of contribution from telecom in our sample can be explained by the fact that none of the IPOs belong to this sector. There are few telecom firms in Norway and the current index is comprised of only two firms; NextGenTel Holding and Telenor. Second, the contribution to our sample from the information technology sector is much larger than the contribution to the OSE. This can be explained by the extremely high market capitalization of BNOK 46.9 of REC Silicon at the time of the IPO in 2006. In comparison, the second largest IT IPO in our sample has a market capitalization of MNOK 818, and the largest firm currently in the OSE45 index has a market capitalization of BNOK 8.2. Moreover, although REC Silicon is included in the industry index, the share value has dropped significantly since its IPO in 2006, and the firm currently (end-May 2016) has a market capitalization of BNOK 4.9. Lastly, health care and consumer discretionary are over-represented in our sample, whereas

materials and consumer staples are under-represented. The small contribution of materials in our sample compared to OSE can be explained by firms with a relatively small market capitalization going public in our period, while large firms like Yara and Norsk Hydro are included in the industry index.

Historical IPO activity

The number of firms going public is known to vary over time, and the graph below illustrates the number IPOs on the OSE in the period 1996-2015.

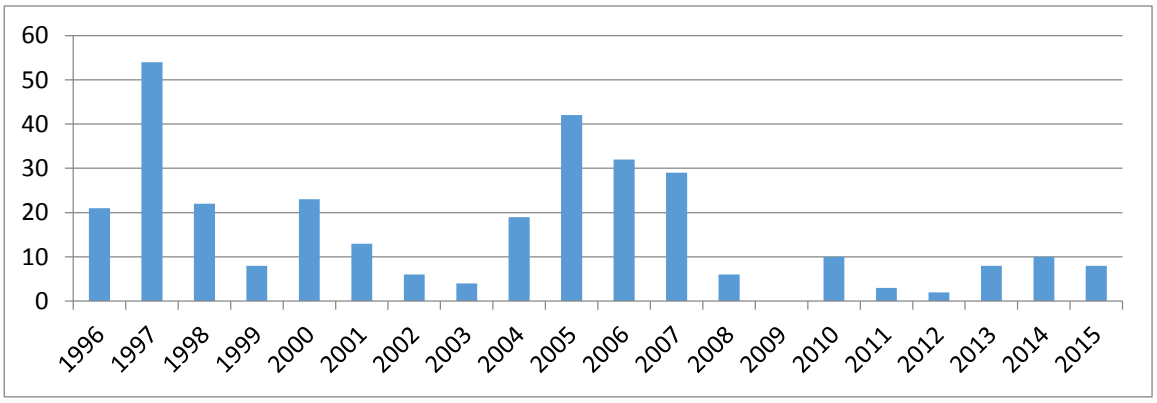

Figure 3: Number of IPOs on the OSE in the period 1996-2015. Source: Adapted from Oslo Børs (2016j).

We observe that the number of initial public offerings in Norway varies substantially over time, and there seems to be a relationship between the number of listings and the state of the world economy. Both in the late 1990s, prior to the burst of the internet bubble in 2000, and leading up to the financial crises in 2008, we observe a high number of IPOs each year. The variation in IPO activity on the OSE is in line with the "hot issue" markets phenomenon, first introduced by Ibbotson and Jaffe (1975). Periods of high initial returns tend to be followed by a large number of IPOs, and periods of decreasing returns are usually followed by modest IPO activity. This will be discussed more thoroughly in the next section.

2.2. Previous evidence of underpricing

A characteristic of IPOs that has puzzled economists for decades is underpricing. Underpricing refers to the phenomenon that issue shares often trade at a significantly higher price in the after-market compared to the offer price set prior to the first day of trading. Underpricing is estimated as the percentage difference between the offer price and the price at which the shares subsequently trade in the market, commonly measured by the first-day closing price. The largest first-day return in the history of NASDAQ occurred when the tech firm VA Linux went public in 1999 with an offer price of $30 per share. During the first day of trading, the share price went as high as $320 before it closed at $239.25. Thus, the estimated underpricing was 698 percent (Bloomberg 2015).

At first glance, the ones that clearly benefit from underpricing are the investors that invested in the IPO shares, as they can sell their shares in the after-market and earn an abnormal return. However, the ones that bear the cost of underpricing are the pre-IPO owners (issuing firm). Since the shares could have been sold to the public at a higher price, the issuer experiences a wealth loss, commonly referred to as "leaving money on the table" (Loughran and Ritter 2002). In the case of VA Linux, the owners left approximately $1 billion on the table. The behavior of leaving money on the table seems irrational, and clearly violates the efficient market hypothesis. However, evidence from the stock exchanges show that underpricing has been a clear trend worldwide for decades.

Many researchers have investigated the IPO underpricing phenomenon, and empirical studies of underpricing dates back to the early 1970s with Reilly and Hatfield (1969), Stoll and Curley (1970), Logue (1973) and Ibbotson (1975), all of which confirm the existence of IPO underpricing in the U.S. Since then, the underpricing puzzle has been investigated by numerous studies all over the world, some of which we will discuss more thoroughly in section 2.4.

2.3. Underpricing of Norwegian IPOs

The empirical research of underpricing in Norwegian IPOs has not been extensive. However, a few studies have documented the presence of underpricing in Norway. Emilsen, Pedersen and Sættem (1997) find an average initial return of 12.5 percent among Norwegian IPOs between 1984 and 1996. Later, Fjesme (2015) reports an average first-day return of 9.99 percent among 188 companies going public on the OSE between 1993 and 2007. Banerjee and Shrestha (2011) report an average simple underpricing of 4.33 percent in the period 2000-2006. Altogether, this indicates that the underpricing of Norwegian IPOs has decreased over the years. Lastly, Loughran, Ritter and Rydqvist (2015) recently published an updated overview of historical underpricing in 52 countries, and the graph below illustrates the underpricing in Europe and the U.S.

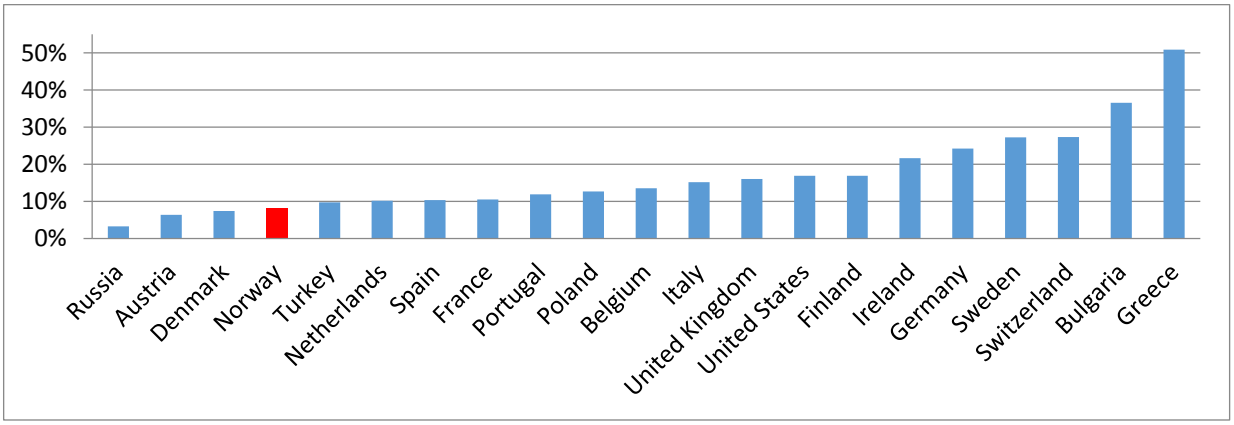

Figure 4: Underpricing in Europe and the U.S. Source: Adapted from Loughran, Ritter and Rydqvist (2015).

The average underpricing of Norwegian IPOs between 1984 and 2013 is estimated to 8.1 percent, which is relatively low compared to the rest of Europe and the U.S. However, the most severe initial return is observed in developing and semi-developed countries like Saudi Arabia (239.8 percent), Jordan (149 percent), China (118.4 percent), and India (88.5 percent). The difference in underpricing between countries has been the focus of many studies. Engelen and Essen (2010) study the levels of underpricing in 21 countries (Norway is not included) in the period 2000-2005, and find that some of the variation can be explained by country-specific characteristics like legal framework (investor protection), the quality of the legal system, and the level of legal enforcement. Similarly, Banerjee and Shrestha (2011) study 36 countries (Norway is included) in the period between 2000 and 2006, and find that underpricing is higher in countries with more information asymmetry, lower home-country bias among investors, higher levels of legal enforcement (higher litigation risk), and less effective contract mechanisms (anti-self-dealing index). Consequently, the relatively low underpricing of Norwegian IPOs may be explained by the high-quality legal system and good investor protection. However, the focus of our study is not to try and explain the difference between underpricing in Norway and other countries, but rather to explain the reasons for the existence of abnormal IPO returns in Norway. Even though underpricing has been the focus of numerous studies during the past decades, no author or theory has been able to fully explain the level of underpricing. In the next section we will review the most prominent and empirically supported theories of underpricing, and discuss to what extent these theories are able to explain the puzzle.

2.4. Theories of underpricing

To organize the available theories of IPO underpricing, we primarily use the grouping of Ljungqvist (2007). He divides the underpricing theories into four main categories; theories based on asymmetric information, institutional explanations, control theories and behavioral explanations. We have added an extra category, risk compensation theory, due to the relevance this category has for our thesis. In addition, we have chosen to take a closer look at a specific model comparing the two pricing mechanisms used for pricing offer shares in Norway. The model is directly related to one of our hypotheses, and is also connected to several of the most relevant theories in our thesis.

Some of the theories provided by Ljungqvist are not of relevance for our thesis due to the characteristics of OSE or the low degree of empirical support, and are thus excluded. Moreover, the theories developed in order to explain underpricing are often interconnected and not mutually exclusive. One theory is often conditioned on, supported by or influenced by other theories, and the empirical studies often test several theories simultaneously.

Consequently, some theories will only be presented shortly. Our main focus will be on the most acknowledged theories in previous IPO literature that have also received the most empirical support. These theories are used as motivation for our hypotheses.

2.4.1. Theories based on asymmetric information

Recall that the main parties to an IPO are the issuing firm, the investment bank (underwriter), and the investors. Investors can further be divided into informed (mostly institutional investors) and uninformed (mostly retail investors). Theories of asymmetric information are based on the assumption of one party having more or superior information compared to another (Ljungqvist 2007). This could be the underwriter being more informed about demand conditions than the issuer, or the issuer knowing more about internal projects than the investors or underwriters.

Theories based on asymmetric information have received the most attention in the literature, and are until now the theories that best explain the reasons for underpricing. However, according to Ritter and Welch (2002), even though theories based on asymmetric information can explain reasons for underpricing, they lack the power to explain **differences in levels** of underpricing. Still, we will focus mostly on these theories as three of our hypotheses are motivated primarily by asymmetric information (revision of offer price, book-building and underwriter reputation).

Winner's curse

Given the on average high one-day return of IPOs, one could ask why not all investors would participate in public offerings. Assume an uninformed investor decides to participate in all new IPOs to earn an on average high return. When the IPO does not go well, the demand for shares is low and he will receive full allotment. However, when the IPO is successful, the demand for shares is high (due to the informed investors also participating) and he will get a smaller amount of shares than requested. This rationing of shares in profitable IPOs results in the uninformed investors receiving allocations that are biased towards the less-profitable IPOs. The phenomenon that the investor "wins" all the shares in unattractive IPOs and is rationed in the attractive IPOs is referred to as the winner's curse. Thus, to make uninformed investors willing to join the public offering, the underwriter choses to underprice the new shares to attain full subscription (assuming that the group of informed investors is not large enough) (Berk & DeMarzo 2014, 822).

The winner's curse theory was first proposed by Rock in 1986, and is up to this date the most influential theory of underpricing. Rock (1986) constructs an adverse selection model with the presence of both informed and uninformed investors. The IPO shares are priced using the fixed-price method and the issuer is not able to acquire pricing-relevant information from the (informed) investors before the offer price is set. Thus, informed investors have an advantage as they can participate in only the undervalued IPOs, while the uninformed investors will invest in both undervalued and overvalued IPOs. According to Rock (1986), the uninformed investors will experience a winner's curse, and are left with a return equal to the riskless rate. As a result, the issuer has to price the shares at a discount in order to persuade the uninformed investors to participate in the IPO. Thus, according to Rock's (1986) theory, the underpricing of shares is a

rational action taken by the issuer in order to induce uninformed investors to participate in the IPO market.

The main empirical implication of the winner's curse, namely that adjusted for allocations, the uninformed investor will earn the riskless rate, have been tested in markets that impose strict allocation rules. Evidence from the U.K. (Levis 1990), Finland (Kelohariu 1993) and Israel (Amihud, Hauser, and Kirsh 2003) show that the uninformed investors (small applications) earn an allocation-weighted initial return lower than the informed investors (larger applications). However, testing the winner's curse is not straight-forward because it involves distinguishing between informed and uninformed investors. Using retail versus institutional or large applications versus small may not always be optimal, as there can be major differences within the groups of investors (Ljungqvist 2007).

Beatty and Ritter (1986) build on Rock's (1986) model with informed and uninformed investors, and introduce ex-ante uncertainty in order to explain the abnormal initial returns. They argue that greater uncertainty about the value of the shares intensifies the winner's curse as there is more to lose for the potential investor. Thus, greater ex-ante uncertainty should be associated with more underpricing. The relationship between uncertainty prior to the IPO and underpricing is easier to empirically test, and will be discussed in more detail under risk compensation.

The winner's curse theory has also received some criticism. In contrast to Rock's (1986) assumption of informed investors being able to avoid overpriced IPOs, Benveniste and Spindt (1989) argue that institutional investors invest in both under- and overpriced offerings. Their theory states that informed investors are afraid of being excluded from future IPOs if they do not invest in overpriced deals. Evidence in support of this is found by Hanley and Wilhelm (1995).

Information revelation theories

Information revelation theories assume that informed investors have an informational advantage over the issuer and other investors, and the main focus of these theories is how this favorable information is revealed. If the informed investors disclose positive information (high demand for shares) prior to the IPO, the issuer will most likely increase the offer price, thereby reducing the profit that the informed investors would have earned if they withheld their private information. Consequently, to induce the informed investors to reveal their favorable information, the underwriters have to compensate the investors through allocation and underpricing of offer shares according to the investor's expected profit loss from revealing their private information (Ljungqvist 2007). In the following, we present the most relevant theories based on information revelation.

Pricing mechanisms

The book-building mechanism can be used to facilitate information revelation and consequently, mitigate the winner's curse (potentially solve the asymmetric information issue). During the book-building process, after collecting non-binding contingent orders from potential investors, the underwriter will allocate the shares based on bids. Investors with low bids will be punished with few or none of the stocks, while investors that bid high will be awarded with a large proportion of the shares. Investors need to be compensated for revealing their strong interest, which explains the underpricing associated with book-building. This theory is supported by Benveniste and Spindt (1989), Benveniste and Wilhelm (1990) and Spatt and Srivastava (1991).

Relevant for our analysis is not only the effect of book-building on the level of underpricing, but rather the comparison of the two pricing mechanisms used in Norwegian IPOs (book-building and fixed-price) and their effect on the level of underpricing. Benveniste and Busaba (1997) have developed a model that is based on the fixed-price approach in Welch (1992) and the book-building method in Benveniste and Spindt (1989). This model is highly relevant for our thesis as it compares the two most prevalent IPO marketing methods in Norway, and we will present the model below.

The model

In the paper "Book-building vs. Fixed-Price: An Analysis of Competing Strategies for Marketing IPOs" from 1997, Benveniste and Busaba compare two mechanisms for pricing IPO shares, namely the fixed-price method and American book-building. The models are set in an environment where investors have correlated information and can observe each other's subscription decision. In the next part, we will reproduce the fixed-price and the book-building models, but firstly we will present the underlying assumptions of the model. The model is carried out in a framework resembling Welch's (1992) model (format and terminology), while the notation resembles that of Benveniste and Spindt (1989).

The issuer and underwriter

An individual firm is assumed to be selling a fixed fraction of ownership in the form of Q shares. The issuer and the investors are equally informed about the firm's prospects. However, the underwriter can ask the investors about their private signal without other investors observing the answer.

The shares

The true value of shares, V, is assumed uniformly distributed between an upper value (V^U) and a lower value (V^L). As a consequence, we can assume $V^U > V^L$. The issuer's reservation value V^P is below V^L. Welch (1992) argues that the difference between V^L and V^P can be interpreted as the capital requirements of the issuer (i.e. the loss incurred if the IPO fails and the issuer has to arrange

a new offering or acquire capital elsewhere). Hence, the issuer will go through with the IPO for every price between V^L and V^U.

Moreover, the authors follow Welch[$p = (1-\theta)V^L + \theta V^H$] and define an unknown offering type as

$\theta = \frac{V - V^L}{V^U - V^L}$,

where $V = p$ and $V^U = V^H$.

The unknown type of issue is assumed to have a uniform distribution over the interval [0, 1], and a mean of 0.5. Thus, a type 0 offering is worth V^L, a type 0.5 offering is worth $\frac{V^L + V^U}{2}$, and a type 1 offering is worth V^U.

The Investors

The authors assume that there is a total of H investors who want to buy at most one share each (i.e. decides between buying one share or abstaining from buying any), and each investor costlessly observes a private signal about the true share value iϵ {U,L}. For an offering of type θ, i is drawn from a Bernoulli variable {U,L} with the probability of U being θ. Combined, the signals observed by the investors can with high precision identify the true value of the shares (V, or equivalently the value of θ). For example, if the after-market value of the shares is three quarters into the range of possible values, for every investor observing an L signal there are three investors with U signals. The investors do not communicate their signal to each other, but they observe the purchasing decision of others. Lastly, the investors are assumed to be risk-averse, and their reservation prices are determined by the expected share value based on their private signals and additional signals that they may learn during the process (formally, the investors' conditional expectation of θ).

The mathematical facts

Fact 1: Assuming that the number of total signals (H) that are good (U signals), are h, an investor's expectation of θ is given by the follow Bayesian rule:

(1) $\theta_h \equiv E(\theta|h;H) = \frac{h+1}{H+2}$.

Fact 2: The number of good signals h can be any H+1 possible outcomes, all of which are equally likely with a probability of

$\pi_h \equiv \Pr(h\ U\ signals; H\ investors) = \frac{1}{H+1}$,

and the ex-ante probability of observing h or more U signals is

$\Pr(h \geq k; H\ investors) = (H - k + 1)\pi_h = \frac{H-k+1}{H+1}$, h=0,…,H.

Since the individual investors consider the action of others when making their decision, Benveniste and Busaba argue that we must consider how each investor perceives the remaining signals in the total group of investors. This leads to fact 3.

Fact 3: Conditional on observing a U signal, an investor believes that there are h U signals in the remaining H-1 signals with probability:

(2a) $\pi'_h \equiv \Pr(h; H-1|U\ signal) = \frac{2(h+1)}{H(H+1)}, \quad h = 0, \dots, H-1.$

On the other hand, conditional on observing an L signal, an investor believes that there are h U signals with the remaining H-1 investors with probability:

(2b) $\pi''_h \equiv \Pr(h; H-1|L\ signal) = \frac{2(H-h)}{H(H+1)}, \quad h = 0, \dots, H-1.$

Proof of this can be found in appendix 1.1.

The marketing of new issues

In this section of the paper, Benveniste and Busaba compare the fixed-price method to the book-building method for the marketing of new issues. First, the fixed-price model is presented and the authors follow the approach of Welch (1992).

The fixed-price method

We start by presenting the underlying assumptions of the issuer and the investors in this model.

The issuer (and underwriter)

The issuer is assumed to set the offer price without formally attempting to obtain the investors' valuations. Since the issuer's objective is to maximize IPO proceeds, setting an offer price using the fixed-price method involves weighing the benefits of setting a high price against the increased likelihood that the IPO will fail if the price is set too high. The offer price is denoted P^o, and the unsold shares are worth the reservation value of the issuer θ^P(normalized value of V^P).

Investors

Investors are assumed to factor all obtained ex-ante information into their expectation of θ. Moreover, the investors hold private information that the issuer do not learn prior to the IPO.

Investors are lined up in order j=1,...,H, and each decides to purchase or not (d_j) based on their reservation price P_j^r. The reservation price of investor j can be expressed as a function of his private signal i_j and the observed purchasing decision of earlier investors, i.e. whether earlier investors purchased shares or abstained. Thus,

(3) $P_j^r(i_j; d_{j-1}, d_{j-2}, \dots, d_1) = E(\theta | i_j \text{ and } d_{j-1}, d_{j-2}, \dots, d_1)$.

Investor j decides to purchase only if his reservation price is equal to or higher than the offer price, i.e. if $P_j^r \geq P^o$. Thus, investor j's purchasing decision reveals his private signal if and only if the following condition holds:

(4) $P_j^r(U; d_{j-1}, d_{j-2}, \dots, d_1) \geq P^o > P_j^r(L; d_{j-1}, d_{j-2}, \dots, d_1)$.

If (4) holds, a decision to purchase shares at the offer price (P^o) reflects a U signal, whereas abstaining reflects an L signal.

Cascades

If (4) is violated at some point in the selling process, a positive or negative cascade is created. If, for example, the offer price (P^o) is lower than both reservation prices, investor j will purchase the shares regardless of his private signal. The following investor (j+1) can verify that (4) is not met for investor j, and thus he cannot figure out what signal investor j had. Consequently, he faces the same purchasing decision as investor j, and decides to purchase. The same is true for all following investors, and a positive cascade is created. Conversely, if (4) is not met and the offer price (P^o) is higher than both conditional reservations prices, starting from investor j, none of the investors following down the line will decide to purchase.

Thus, based on the investors' expectation of θ, the issuing firm can create an immediate positive cascade by setting the offer price equal to or below 1/3 conditioned on the first investor observing an L signal $\left(\theta_h = \frac{0+1}{1+2} = \frac{1}{3}\right)$. This ensures a successful IPO. On the other hand, if the issuer sets the offer price higher than 2/3 conditioned on the first investor observing a U signal, he will create a negative cascade $\left(\theta_h = \frac{1+1}{1+2} = \frac{2}{3}\right)$. For offer prices in between, $\frac{2}{3} \geq P^o > \frac{1}{3}$, the outcome of the offering depends on the number (n) of investors who choose to purchase offer shares, which in turn depends on the distribution of the signals. If a sufficient number of early signals are positive, this could trigger a positive cascade, and vice versa. Consequently, the firm's expected proceeds can be expressed as:

$E\{\tilde{n}(P^o)P^o + [Q - \tilde{n}(P^o)]\theta^P\}$,

where $\tilde{n}(P^o)$ denotes the distribution of investors choosing to purchase (n) as a function of the offer price. This leads to theorem 1.

Theorem 1: The offer price that maximizes the expected proceeds is $P^o = \frac{1}{3}$. At this price, $n = Q$ and the expected proceeds are exactly $\frac{Q}{3}$. *For proof, see appendix 1.2.*

The expected underpricing, calculated as the difference between the unconditional expected share value (1/2) and the offer price (1/3), is 1/6. Moreover, from theorem 1 we observe that the expected investor demand is elastic at the optimal price so that an increase in price reduces the expected proceeds. As shown in the appendix, the probability of creating a negative cascade increases with the price, and a negative cascade is costly due to $V^P \leq V^L$. Following Welch (1992), the optimal price of 1/3 translates into a price of $V^L + \frac{V^U - V^L}{3}$, and the expected underpricing becomes $\frac{V^U - V^L}{6}$ (proof can be found in appendix 1.3). Lastly, the expected underpricing increases with ex-ante uncertainty in offer value, here denoted ($V^U - V^L$).

The book-building method

Again, we start by introducing the underlying assumptions of the model.

Issuer

Before having to make the final price decision, the issuing firm receives aggregate demand collected from potential investors, thus eliminating any informational disadvantage the firm may have. Moreover, the issuing firm reveals the collected information to all investors, eliminating any information asymmetry between uninformed and informed investors.

Underwriter

The underwriter's objective is to maximize expected proceeds, subject to the incentives of investors. To induce investors to be honest about their private information (U or L), the underwriter establishes a mechanism, referred to as the price/allocation schedule. This schedule is conditioned on the gathered non-binding indications of interest from potential investors in the pre-market. That is, the outcome of the pre-market is represented by the number h of investors revealing U signals. This outcome is revealed to investors, and the price/allocation schedule is put in place (conditioned on both the cumulative pre-market outcome and on the individual responses of investors).

Investors

In the model, it is assumed that investors reveal either a U (positive) or an L (negative) signal. After the pre-market outcome is collected by the underwriter and the price/allocation schedule is put in place, investors revise their expectation of the issue type θ_h, which becomes their reservation value.

The following notation is used to describe the price/allocation schedule:
$P_h^o = the\ offer\ price\ when\ h\ of\ the\ H\ investors\ reveal\ U\ signals;$
$q_{L,h} = the\ allocation\ to\ an\ investor\ who\ reveals\ an\ L\ signal\ when\ h\ others\ reveal\ U\ signals;$
$q_{U,h+1} = the\ allocation\ to\ an\ investor\ who\ reveals\ an\ U\ signal\ when\ h\ others\ do\ the\ same.$

Firstly, the marginal value of an investor's signal can be expressed as:

(5) $\theta_{h+1} - \theta_h = \frac{h+2}{H+2} - \frac{h+1}{H+2} = \frac{1}{H+2}$.

If an investor with a U signal falsely reveals an L signal, he drives the perceived issue type from θ_{h+1} to θ_h. We observe that the marginal value of private information is decreasing in the number of pre-market investors revealing their interest (H).

An investor with a U signal who reveals an L signal has the following expected profit in the pre-market:

(6) $\sum_{h=0}^{H-1} \pi'_h[\theta_{h+1} - P_h^o]q_{L,h}$,

where π'_h denotes the conditional probability that h others will reveal a U signal. This equation is built on the assumption that the after-market price efficiently incorporates all information, and that the other investors (H-1) reveal truthful information.

On the other hand, if the investor with a U signal truthfully reveals his signal, his expected profit is:

(7) $\sum_{h=0}^{H-1} \pi'_h[\theta_{h+1} - P_{h+1}^o]q_{U,h+1}$.

In order to induce investors to reveal truthful information, the profit from (7) needs to be higher than the profit (6). Thus, using (5), this condition can be written as:

(8) $\sum_{h=0}^{H-1} \pi'_h[\theta_{h+1} - P_{h+1}^o]q_{U,h+1} \geq \sum_{h=0}^{H-1} \pi'_h \left[\theta_h - P_h^o + \frac{1}{H+2}\right] q_{L,h}$.

Moreover, the offer price can never exceed the reservation price of investors since indications are non-binding, that is,

(9) $P_h^o \leq \theta_h, \;\; h = 0, \dots, H.$

Equation (8) is referred to as the incentive compatibility constraint, and to make sure that this constraint holds, underpricing may be necessary. That is, if investors expect to profit from falsely revealing their information, the underwriter needs to induce them to reveal truthful information using price discounts.

To determine the price/allocation schedule that maximizes the expected proceeds, the following maximization problem must be solved:

(10) $\max_{\{P_h^o, q_{L,h}, q_{U,h+1}\}} \sum_{h=0}^{H} \pi_h \{Q\theta_h [h q_{U,h} + (H-h) q_{L,h}](\theta_h - P_h^o)\},$

subject to constraint (8) and (9), and

(11)

$0 \leq q_{L,h} \leq 1, \qquad h = 0, \dots, H-1,$

$0 \leq q_{U,h} \leq 1, \qquad h = 1, \dots, H,$

$h q_{U,h} + (H-h) q_{L,h} = Q, \qquad h = 0, \dots, H.$

These constraints are based on the assumption that each investor can buy no more than one share, and that the entire issue (Q) is placed. The solution to this problem leads to theorem 2.

Theorem 2: The maximum expected proceeds are achieved under the following conditions:

1. $when\ h < Q, set\ q_{U,h} = 1, q_{L,h} = \frac{Q-h}{H-h}, and\ P_h^o = \theta_h;$
2. $when\ h \geq Q, set\ q_{U,h} = \frac{Q}{h}, q_{L,h} = 0, and\ P_h^o = \theta_h - u_h.$

Under the first condition, there are more shares to be allocated than investors revealing positive information. Thus, the investors revealing a U signal will be allocated one share each, and the investors revealing an L signal have to split the remaining shares. Moreover, the shares are priced at the investors' reservation value.

Under the second condition, there are more positive (U) signals than shares available. Thus, the offer shares will be divided amongst the investors revealing U signals, whereas the investors revealing an L signal will receive no shares. When there are enough investors revealing positive signals to purchase the whole issue (Q), the issuer will underprice the shares. In this case, the expected underpricing following the proceed-maximizing strategy is given by

$$E(u_h) = \sum_{h=Q}^{H} \pi_h u_h = \left(\frac{\sum_{h=0}^{Q-1} \pi'_h \frac{Q-h}{H-h}}{\frac{Q}{H}} \right) \left(\frac{1}{2(H+2)} \right).$$

Further, this strategy yields the following expected proceeds (per share):

$E(P^o) = ½ - E(u_h)$.
(For proof, see appendix 1.4).

Following this strategy will minimize the underpricing needed to induce truthful information revelation, and it leads to the smallest amount of money left on the table for the issuer. The underwriter gives allocation priority to the investors revealing positive U signals, and underpricing is only required when these investors can buy the whole issue (when h≥Q). Thus, the pricing/allocation schedule minimizes the benefit to investors who misrepresent their U signals as Ls, and consequently, minimizes the level of underpricing needed to satisfy the incentive compatibility constraint (8).

From these results, several conclusions can be drawn. Firstly, for a given offer size, Q, the expected underpricing decreases with the total number of investors polled in the pre-market, H.
Proof of this can be observed by substitution $\pi'_h = \frac{2(h+1)}{H(H+1)}$ (from fact 3) into $E(u_h)$, which gives:

$$E(u_h) = \sum_{h=Q}^{H} \pi_h u_h = \left(\frac{\sum_{h=0}^{Q-1} \left(\frac{2(h+1)}{H(H+1)} \right) \left(\frac{Q-h}{H-h} \right)}{\frac{Q}{H}} \right) \left(\frac{1}{2(H+2)} \right).$$

Here it is clear that when H increases, $E(u_h)$ decreases.

Secondly, the expected underpricing increases with the range of possible true share values ($V^U - V^L$). Proof of this is can be found by substitution original values into expression (5), where the marginal value of information becomes

$$\frac{(V^U - V^L)}{H+2},$$

and expected underpricing (theorem 2) becomes

$$(V^U - V^L)E(u_h),$$

which shows that expected underpricing is increasing in $(V^U - V^L)$. Moreover, for investors to truthfully reveal their favorable information, the compensation for revealing U signals instead of L signals has to equal the difference between the lower share value (V^L) and the upper share value (V^U) (condition 8 must hold). However, as mentioned earlier, underpricing only occurs if h≥Q. These results indicate that when the ex-ante uncertainty increases (i.e. the range of possible values increases and makes it harder to correctly value the shares), the value of private information increases. Consequently, the incentive to reveal false information increases, and the underwriter has to underprice the shares more to induce the investors to be truthful. This leads to theorem 3.

Theorem 3: The ratio of underpricing to the offer price increases with a mean-preserving spread of $(V^U - V^L)$.
Proof of this can be found in appendix 1.5.

Comparing the results
Assuming that the issuer follows the proceed-maximizing strategy, the proceeds from a book-building issue will have higher expected value than the proceeds from a fixed-price issue as long as H>1.

To illustrate this, assume that H=Q, which is the case when pre-marketing underpricing is the highest. In this state, the underpricing only occurs if h=H=Q. Substituting into (A-4) from appendix 1.4. leads to the expression:

$$E(u_h) = \sum_{h=Q}^{H} \pi_h u_h = \left(\frac{\sum_{h=0}^{Q-1} \left(\frac{2(h+1)}{H(H+1)}\right)\left(\frac{H-h}{H-h}\right)}{\frac{H}{H}} \right) \left(\frac{1}{2(H+2)}\right),$$

and the expected underpricing per share equals $E(u_h)$=$\left(\frac{1}{2(H+2)}\right)$. When H=1, the expected underpricing per share is $\left(\frac{1}{2(1+2)}\right) = \frac{1}{6}$ in the book-building model, which is the same as in the fixed-price model. However, when H>1, the underpricing will be lower with book-building than with fixed-price.

The fact that expected proceeds are higher when the book-building mechanism is used to price the offer shares indicates that the cost of acquiring private information from investors is lower than the cost of preventing a negative cascade in a fixed-price offering. In a fixed-price offering, the required underpricing is determined by the full value of the private signal of the investor who is first in line. In comparison, the underwriter building a book solely targets investors with positive signals, and only has to underprice the shares to reflect the marginal value of investor signals. As we have seen, the underpricing is decreasing in the number of signals revealed by investors (H). Moreover,

the underwriter can discriminate in share allocations so that investors who falsely reveal a negative signal face the risk of ending up with few or no shares.

However, the proceeds from a book-building issue will have higher ex-ante variability than the proceeds from a fixed-price issue. This is because the proceeds from a fixed-price issue are certain, while the book-building proceeds are contingent on the investor interest revealed in the pre-market.

The option value of book-building

In the final part of the paper, Benveniste and Busaba consider the option value of book-building. We will briefly explain the motivation behind, and the outline of this model. The authors argue that additional benefits can be obtained in the book-building process due to information revelation. This could be information that helps the issuer evaluate its strategy, or information that can help the firm raise additional capital at a lower cost. To illustrate the option value of book-building, Benveniste and Busaba let the offer size, Q, be determined by the issuer (i.e. the issuer holds an option to adjust the issue size). The conclusion from the fixed-price model remains unchanged; however, in the book-building model the issuer can set a higher offer price. When h>Q, the issuing firm can increase the offer size to meet the excess demand without increasing the discount on the offer price. Hence, the underpricing per share will be lower. Moreover, the issuer can extend and over-allotment option which enables the underwriter to sell additional shares in the after-market at full value (that are underpriced at the margin).

After considering the option value of book-building, Benveniste and Busaba compare the two pricing mechanisms and reach their conclusion: Book-building generates higher expected proceeds and exclusively provides an opportunity to sell additional shares at full value. However, this method exposes the issuer to greater risk. In comparison, fixed-price offerings priced at the cascade price guarantee the issuer certain proceeds, and thus this method may be preferred by risk-averse issuers or issuers facing more price uncertainty.

Empirical findings

Several empirical studies compare the efficiency of different pricing mechanisms on the level of underpricing, and the majority find that book-building is a more efficient pricing mechanism than fixed-price in line with the model by Benveniste and Busaba (e.g., Benveniste and Wilhelm 1990; Spatt and Srivastava 1991; Biais and Faugeron-Crouzet 2002).

However, more recently Busaba and Chang (2010) found that unless the underwriter can target only a small subset of informed investors in the book-building process, using fixed-price is more efficient and requires less underpricing on average. Moreover, Ljungqvist, Jenkinson and Wilhelm (2003) find that the efficiency of book-building only holds for the combination with U.S. banks and U.S. investors, while fixed-price offerings are associated with less underpricing in European IPOs.

However, these findings may be explained by the fact that choice of pricing mechanism is endogenous, depending on firm characteristics. This is in line with the conclusion of Benveniste and Busaba (1997); that the fixed-price method is optimal for issuers facing more price uncertainty and issuers that are more risk-averse, whereas firms that will benefit from the over-allotment option (greater capital needs) prefer the book-building method.

Revision of offer price

Revision of offer price can be considered an extension of the book-building theory. Benveniste and Spindt (1989) investigate the relationship between investors' disclosure of private information and the subsequent offer price revision. If positive information is revealed during the book-building period, the final offer price is often set above or at the upper end of the indicative price range, and vice versa. However, as noted by Ibbotson, Sindelar and Ritter (1988), the offer price is usually only partially adjusted to the private information disclosed. Hanley (1993) was the first to empirically document this phenomenon and defined it as the "partial adjustment" phenomenon. As a consequence of this partial adjustment, the spread between the final offer price and the "true" value of the shares is given to investors as compensation for disclosing their favorable information.

An alternative explanation of the relationship between offer price revision and underpricing is given by Edelen and Kadlec (2005). They explain the partial adjustment to public information as a trade-off between proceeds and the likelihood of a successful IPO. The authors develop a model in which rational issuers follow a pricing policy that maximizes the expected surplus from going public, and weighs the benefit of greater proceeds in case of a successful IPO against the cost of forgone surplus if the IPO fails. The issuer adjusts its expectations of IPO share value based on the valuation of comparable firms. An increase in the market valuation of similar firms indicates higher proceeds for the firm going public, and the issuer responds with a partial revision of the offer price because the marginal benefit of increasing the probability of a successful IPO is high. Put differently, the issuer becomes more risk-averse as the expected proceeds of going public increases, resulting in a less aggressive pricing. Conversely, a decrease in the expected surplus due to low comparable firm valuation would lead to a more aggressive pricing of the shares. In this case, the marginal cost of increasing the probability of an IPO failure is low, and the issuer will set the offer price as high as possible to maximize the potential profits. Consequently, Edelen and Kadlec (2005) hypothesize that underpricing should increase with the value of comparable companies.

Principal-agent models

Principal-agent models focus on the moral hazard that arises when the underwriter (agent) is better informed than the issuer (principal), and the issuer is not able to monitor the agent to ensure that he is acting in the best interest of the principal. This is especially the case when the underwriter can make choices that are beneficial for himself at the cost of the issuer (Ljungqvist 2007).

Baron (1982) develops a model in which the underwriter is responsible for the pricing decision of the issuer. In the model, underwriters find the cost related to marketing activity higher than the expense of underpricing, thus they tend to underprice IPOs to minimize their selling effort. However, Rock (1986) claims that Baron's model is simplistic as it does not consider the competitive environment the underwriters face and the fact that underwriters value their reputation. He argues that an increase in the size and reputation of the underwriters boost their desire to maintain a valuable reputation, making them motivated to reveal truthful information and underprice less.

Moreover, Muscarella and Vetsuypens (1989) study the IPOs of 38 investment banks where the investment banks underwrite their own IPOs. There should be symmetric information and no conflicts of interest as the issuer and underwriter are one and the same. Nevertheless, their findings indicate that the level of underpricing is similar to the underpricing of firms facing asymmetric information. Thus, their evidence contradicts the principal-agent theory.

Underpricing as a signal of firm quality

The signaling theory is based on asymmetric information between the issuer and the investors. Issuers that are better informed than investors regarding the present value of future cash flows or firm-specific risk may set a low offer price or issue a lower fraction of shares to signal the company's true high value. Ibbotson (1975) explains the underpricing phenomenon as the issuer's desire to "leave a good taste in investors' mouths", where high-quality firms can recoup their losses (cost of underpricing) in the future through better terms in subsequent offerings. On the other hand, low-quality firms that are aware of their expected performance and true market value cannot afford to copy the costly signal of high-quality firms, as they will not be compensated in subsequent offerings. Consequently, underpricing can be considered a credible signal for firm quality (Allen and Faulhaber 1989).

Bustamante (2012) develops a signaling model in which firms with better investment prospects (good types) can use IPO timing, fraction of shares issued and underpricing to signal their quality in order to avoid imitation by firms with worse investment prospects (bad types). In the basic model, good types can only use IPO timing as a signal of quality when there is asymmetric information between the issuer and outside investors. The strategies the good types can choose between are; going public earlier, attain a higher market value, and pay the signaling costs (separating equilibrium), or; go public later, attain a lower market value, but avoid signaling costs (pooling equilibrium). The choice of strategy depends on the share of good types in the economy. If there is a low share of good types in the market, the value attained from revealing their type to outside investors will be higher than in the pooling equilibrium. This is because the shadow cost of signaling is lower than the cost of being mispriced by going public together with the bad types. However, if the share of good types in the economy is high, firms with better investment prospects

attain a higher value by pooling with the ones with worse investment prospects (issue simultaneously). In this equilibrium, the good types are valued at the average market value of their shares because the outside investor cannot infer the firm type.

Next, Bustamante extends the basic model to include multiple signals: Fraction of shares issued and underpricing. In this model, there are multiple separating equilibria that are incentive compatible. She finds that in the least cost separating equilibrium, the good types attain the highest possible value by ***not*** underpricing their shares (subject to asymmetric information). The good types instead signal through IPO timing (go public earlier) and fraction of shares issued (issue lower fraction of shares). This finding is in line with previous studies on signaling theory which argue that underpricing may be an inefficient signal for revealing private information to outside investors (Grinblatt and Hwang 1989). For instance, the issuer can use alternative signaling mechanism as a certification of quality, like underwriter reputation (Booth and Smith 1986), auditors (Titman and Trueman 1986), or venture capitalist backing (Megginson and Weiss 1991; Lee and Wahal 2004).

However, Bustamante finds an alternative separating equilibrium that involves underpricing of shares, where the underpricing may reflect the shadow cost of signaling in equilibrium. The cost of signaling is reallocated to the outside investors in the form of abnormal returns, thus underpricing can be efficient for the issuer and investor altogether. This stands as a twist to the findings of Grinblatt and Hwang (1989).

Lastly, the author empirically tests the implications of the model using a sample of 4888 U.S. IPOs between 1980 and 2007, and finds that an increase in underpricing is related to a marginal increase in the probability of having a higher SP rank in the 2 years following the IPO. This finding is in line with Ibbotson's (1975) argument that issuers underprice to "leave a good taste in investors' mouths".

Underwriter reputation

As mentioned above, an alternative signaling method to underpricing is the use of reputable underwriters. Firms can hire a prestigious underwriter to signal their low risk (high quality) to the public. Assuming that underwriters want to preserve their reputation (Rock 1986), they will prefer to underwrite less risky IPOs. Thus, if the firms can acquire a reputable underwriter based on information unavailable to the public market, the investors' incentive to obtain information is reduced (i.e. the winner's curse is reduced), and less underpricing is required to compensate uninformed investors for buying shares in the IPO. However, this assumption only holds if the cost of hiring a prestigious underwriter is lower than the cost of signaling firm quality directly through underpricing.

Beatty and Ritter (1986) are the first to introduce the role of underwriter reputation in their study of initial public offerings in the U.S. in the period 1977-82. They begin by explaining that the issuing firm could "cheat" and set the offer price too high since the firm is only going public once and has no incentive to leave money on the table. If this was the case, how would investors be compensated for the risk of investing in possibly overvalued shares? This is where the underwriter comes in to enforce the underpricing equilibrium. Under the assumptions that the underwriter is uncertain about the true value of the shares (i.e. cannot price the shares perfectly and eliminate the winner's curse), has reputation capital at stake (on which it is earning a return), and that the reputational capital can be destroyed if the underwriter sets the price too high or low, the underwriter will choose the equilibrium price. The authors empirically test the relationship between underpricing and underwriters' market share, and find that underwriters pricing "off the line" subsequently experience a fall in market share of about 50 percent. Thus, prestigious underwriters should be associated with less underpricing. This relationship is supported through the 1980s and for the first half of the 1990s by McDonald and Fisher (1972), Logue (1973), Tinic (1988), Carter and Manaster (1990), Carter, Dark and Singh (1998), and Dunbar (2000).

However in the 1990s, Beatty and Welch (1996) discover a reversal of the negative relationship, which is later supported by Loughran and Ritter (2004), and Liu and Ritter (2011). Beatty and Welch (1996) argue that the reversal of the sign is due to differences in the economic environment; whereas Loughran and Ritter (2004) claim that the reversal is due to either the issuer or the underwriter changing their behavior. Their evidence indicates that the behavior of individual underwriters changed during the internet bubble, as reputable underwriters relaxed their requirements and took public an increasing number of young and unprofitable firms.

Later, Liu and Ritter (2011) offer a third explanation for the reversal of the relationship between underwriter reputation and underpricing. They point out that the previous studies do not account for the competition between underwriters, and develop a new theory (local oligopolies theory) that explicitly accounts for interactions between competing underwriters. The model is built on the assumptions that underwriters offer differentiated services, and that competition is localized. Thus, the industry structure is best characterized as a series of local oligopolies where only a subset of underwriters has some market power in each industry. Moreover, only a fraction of issuers are willing to pay for the non-price dimension of underwriting (e.g. underwriter quality, industry expertise, after-market price support, analyst coverage). Their results indicate that during the 1980s, issuers were more price sensitive and hired underwriters primarily based on their fees. This is in line with the certification theory, i.e. that issuers want to maximize IPO proceeds and hiring prestigious underwriters will help reduce information asymmetries, which results in lower underpricing. In contrast, issuers were more concerned about non-price dimensions of underwriting in the 1990s, indicating that they would pay more for underwriting services than in the earlier

periods. This can explain the positive relationship between underwriter reputation and underpricing.

However, Ljungqvist, Jenkinson and Wilhelm (2003) argue that the positive coefficient could be due to endogeneity, and that underwriter reputation may not have a direct effect on underpricing. They explain that underwriter quality influences price revision and therefore only has an indirect effect on underpricing. Lastly, Fjesme (2015) finds no significant relationship between underwriter reputation and first-day returns of Norwegian IPOs between 1993 and 2007.

2.4.2. Risk compensation theory

Ritter (1984) introduced the changing risk composition hypothesis, which states that riskier IPOs should be associated with higher initial returns than less risky IPOs. The more market-wide uncertainty, the harder it is for issuers and underwriters to accurately value the offer shares. This is in line with general financial theory, which states that riskier investments should be awarded with a higher return. Beatty and Ritter (1986) support Ritter's (1984) hypothesis and argue that ex-ante uncertainty affects the underpricing equilibrium. When the ex-ante uncertainty increases, the winner's curse intensifies, and uninformed investors require more underpricing to partake in the offering.

To account for the risk associated with an IPO, a number of risk measures have been presented and tested in the previous literature. The most well-known factors relate to the company (size, degree of establishment, beta value), the issue (size of issue), and the general market conditions before and after the IPO ("hot/cold issue" periods, performance of stock index). In the development of our hypotheses, we focus on risk factors that can be observed prior to the IPO. Beta value and ex-post market conditions are measures that can only be observed after the initial public offering has occurred; hence, these will not be presented.

Age of company

According to Ritter (1984), younger firms with little or no operating history are associated with a great deal of uncertainty regarding the value of their shares. Uninformed investors facing an adverse selection problem will require more underpricing in order to invest in IPOs of younger firms. Older and more established companies are easier to value, and thus, require less underpricing. Dietrich (2012) supports this argument, and further explains that older companies face less uncertainty as they are more established with respect to customer bases, higher degree of operating expertise, more business experience etc. The negative relationship between firm age and initial return is empirically confirmed by several previous studies (e.g. Su and Fleisher 1999; Loughran and Ritter 2004; Chahine 2008).

Size of company

Dietrich (2012) argues that larger firms usually have a more solid financial foundation and are able to diversify their risk more easily through larger customer bases, several market segments etc. Moreover, Liu, Sherman and Zhang (2009) propose that larger companies are exposed to higher analyst coverage during the IPO process, which leads to a reduction of informational asymmetries. Thus, the larger the firm, the less underpricing is needed as compensation for risk. This relationship is empirically supported by Beatty and Ritter (1986), Hanley (1993), and Chambers and Dimson (2009).

On the contrary, Alvarez-Otero and Gonzalez-Mendez (2006) identify higher initial returns among larger firms in the Spanish stock market. However, the contradicting results may be explained by country-specific differences in levels of firm establishment, where the average age and size of firms going public is much higher in Spain than in the U.S.

Market condition

Market return and volatility

Similar to the partial adjustment of offer price following an increase in comparable company valuation explained by Edelen and Kadlec (2005), several researchers have documented that underwriters only partially adjust the price to reflect recent market movements. Derrien and Womack (2003) document a strong positive relationship between market condition (market return and volatility) prior to an offering and the underpricing of French IPOs. For IPOs in the U.S., Loughran and Ritter (2002) report that following periods where the overall market has risen, the average underpricing is 8.47 percent higher than the underpricing following a market decline. This is confirmed by Lowry and Schwert (2002), who additionally identify a stronger adjustment downward when there is a decline in the market than upward following an increase in market performance.

The relationship between ex-ante volatility and underpricing is supported by Lowry, Officer and Schwert (2010) for the U.S. market, however this only holds for times-series return volatility, while the evidence of a relationship between cross-sectional return volatility and initial returns of IPOs is weak. Lastly, Schill (2004) finds that an increase in market volatility has no direct effect on IPO underpricing.

"Hot issue" markets

Ibbotson and Jaffe (1975) introduced the expression "hot issue" markets in relation to IPOs. They observe that IPO activity is cyclical, and define "hot issue" markets as periods in which the average

first-month performance of new issues is abnormally high[1]. However, there exist several possible measures used to identify "hot issue" markets (e.g. number of IPOs, issue volume, risk). Ritter (1984) argues that "hot" ("cold") issue markets occur when a large proportion of the firms going public have high (low) risk, and identifies a "hot issue" market in the U.S. from 1980 to 1981, where the average initial return was 48.4 percent. In the remaining time period between 1977 and 1982, he observes an average initial return of 16.3 percent, and consequently defines these periods as "cold issue" markets. Güçbilmez (2015) and Günther and Rummer (2006) have confirmed the same relationship in other economies like China and Hong Kong, and Germany, respectively.

Similar cyclicality in IPO activity is confirmed by Ibbotson, Sindelar and Ritter (1988) over the time period 1960-1987. However, Ibbotson, Sindelar and Ritter (1988) introduce two alternative explanations for "hot issue" markets, namely positive feedback strategies (momentum) and windows of opportunity. First, investors following a momentum strategy are willing to bid up the price of an issue if there is a positive trend in the IPO market (i.e. if high returns are observed in recent issues). Due to the constraints on short-selling right after the offering, investors following the momentum strategy can end up causing positive autocorrelation of initial returns. Second, windows of opportunity are assumed to occur in periods when investors are overly optimistic about new equity issues. Firms can take advantage of this irrational behavior by timing their initial public offering to periods where investor sentiment is high in order to secure large gross proceeds. Thus, "hot issue" periods should be associated with more underpricing and higher issue volumes.

Lastly, Ritter and Welch (2002) link IPO activity (issue volume) to underpricing in order to investigate the dot-com bubble. They observe an increase from the 1980s (volume of $8 billion per year and average first-day returns of 7.4 percent), leading up to the peak of the internet bubble. During 1999-2000, the volume peaked at $65 billion accompanied by an underpricing of 65 percent, before the bubble burst in 2001, and the volume and the initial return dropped to $34 billion and 14 percent, respectively.

Issue size

As pointed out by Beatty and Ritter (1986), underpricing is mechanically related to offer size. They observe an inverse relationship between issue size and the level of average initial returns, and argue that this is due to the fact that larger issues are associated with lower uncertainty. Guo, Lev and Shi (2006) claim that firms issuing large volumes have the power to bargain for a higher issue price, resulting in lower underpricing. This theory is supported by Ibbotson, Sindelar and Ritter (1994), and Habib and Ljungqvist (2001). However, Cornelli, Goldreich and Ljungqvist (2006) find a negative correlation between underpricing and issue size. They argue that larger issues are subject

[1] Due to lack of first-day trading prices, Ibbotson (1975) measures initial performance using calendar month-end prices.

to a discount in the offer price to reflect the greater difficulty of selling shares in subsequent offerings.

Industry

Several studies have identified that the level of underpricing varies between industries. Ljungqvist, Jenkinson and Wilhelm (2003) argue that industries that face higher valuation uncertainty are associated with higher underpricing than industries that are more stable and mature. The valuation uncertainty is higher for industries associated with more intangible assets, higher uncertainty in future revenue streams, a larger fraction of young firms, more past bankruptcies etc. (Henrick 2012). Thus, construction companies should be associated with lower underpricing than media and publishing, information technology and telecommunications. In support of this, Loughran and Ritter (2002) observe higher underpricing among technology and internet stocks, and Henrick (2012) finds that both technology and consumer services are subject to higher initial returns than other industries. Lastly, Eraydin (2008) studies the Turkey stock market and report that financials are subject to higher underpricing than non-financials.

2.4.3. Institutional explanations

Institutional theories of underpricing focus on features of the market place, such as the after-market price stabilization conducted by investment banks, and the litigation risk in relation to the IPO. The empirical evidence of these theories is mixed, and none of the theories are directly used in the development of our hypotheses. Therefore, we will only present the most prominent institutional theories, namely legal liability and price stabilization (Ljungqvist 2007).

Legal liability

The basic idea behind the legal liability theory is that the issuer deliberately underprices the shares to reduce the likelihood of future lawsuits, should the post-IPO performance of the stocks disappoint the investors. Lowry and Shu (2002) find that almost 6 percent of companies that went public in the U.S. between 1988 and 1995 were sued for violations in relation to the IPO. Their average costs related to the lawsuit were estimated to 13.3 percent of IPO proceeds. In addition to the direct cost of litigation, firms and underwriters also face indirect costs like damage to their reputation. The theory of issuers using underpricing to avoid lawsuits is supported by Tinic (1988), Hughes and Thakor (1992), and Hensler (1995).

However, Drake and Vetsuypens (1993) find evidence that is inconsistent with the lawsuit-avoidance hypothesis. Their study, consisting of 93 firms that were sued after the IPO and 93 firms that were not, conclude with sued firms being just as underpriced as the rest. Moreover, they find that underpriced firms are sued more often than the ones that are overpriced. Lastly, whereas underpricing is present all over the world, the strict liability laws in the U.S. are not. This strongly

suggests that the lawsuit-avoidance theory cannot be the primary explanation for underpricing, but it can still be a possible second-order driver of underpricing.

Price stabilization

The influence of underwriter price support on initial IPO returns was first introduced by Ruud (1993). In contrast to aforementioned theories claiming that issuers deliberately underprice their IPO shares (e.g. Rock 1986; Tinic 1988; Allen and Faulhaber 1989), Ruud (1993) argues that high initial returns can be attributed to price support offered by the underwriters in the secondary market.

According to Ruud (1993), the underwriters prevent the price from falling below the offer price by entering "syndicate bids" at the issue price, thereby stabilizing the offer price in the after-market. Consequently, the mean of the initial return distribution increases as the left tail is eliminated due to the reduced number of negative initial returns (positively skewed). Thus, price support should lead to higher initial returns on average. Further, Ruud (1993) points out that her explanation is consistent with the findings of Muscarella and Vetsuypens (1989) (i.e. that self-underwritten IPOs exhibit levels of underpricing similar to ordinary IPOs). Following Ruud (1993), Schultz and Zaman (1994) and Hanley, Kumar and Seguin (1993) indirectly examine the effect of price stabilization on the offer price and find evidence supporting Ruud's (1993) theory.

Chen and Wilhelm (2008) offer another theoretical explanation for the positive relationship between underpricing and price stabilization. The authors argue that the tendency of placing a large fraction (65-75 percent) of IPO shares with institutional investors reflects an intermediate stage (initial distribution) in the final distribution of the IPO. They develop a dynamic model in which investment banks and institutional investors work together to smooth the initial public offering's transition to the secondary market trading. Under the assumption that significant new information arrives in the market immediately after the IPO, the optimal distribution strategy for the issuer involves intertemporal price discrimination. Due to the strict requirement of uniform pricing of offer shares, the investment banks replicate the optimal strategy by allocating shares to institutional investors which in turn distribute the shares to the secondary market investors. The institutional investors are rewarded for their cooperation by being allowed to participate in future discounted IPOs. Moreover, the authors argue that the discount offered as compensation to institutional investors for not deviating from the strategy is independent of any underpricing that may have arisen during the book-building in order to induce the informed investors to reveal private information. Thus, the price support theory could provide a complimentary explanation to the information revelation theories in explaining the high levels of underpricing.

Fjesme (2015) tests this relationship on the OSE, and confirm the positive relation between price support and first-day returns of Norwegian IPOs. His results indicate that increasing price support by one standard deviation is associated with a 2.3 percent higher initial return.

2.4.4. Ownership and control

Recall that greater ownership dispersion can be considered both an advantage and a disadvantage of going public. Ownership and control theories assess how managers may use underpricing as a strategic tool when allocating shares and control rights in order to either increase or decrease the post-IPO owners' incentives to monitor the firm. If the management wants to prevent monitoring in order to extract private benefits from the company, underpricing could be used to ensure a dispersed ownership by allocating small stakes to each investor. Contrarily, if the management wants to aid monitoring due to high agency costs, underpricing could be used to attract large block holders (institutional investors) (Reiche 2014, 54). However, there exist little empirical evidence supporting the control theories, and it is still unknown if ownership and control are of first or second-order importance in explaining underpricing (Ljungqvist 2007).

Underpricing as a means to retain control

Brennan and Franks (1997) introduce the "reduced monitoring hypothesis" to explain the relationship between underpricing and retention of control. The existing firm owners are sometimes eager to retain control as it allows for expropriation of private benefits. If this is the case, the shares could be offered at a discount in order to create excess demand (oversubscription), which in turn enables the issuer to ration the allocation of shares and to reduce the individual ownership stake of new investors. This ensures a more dispersed ownership and reduces the incentives for new shareholders to monitor the existing management.

Two empirical implications can be formulated based on this theory: 1) if the IPO is oversubscribed, rationing will take place and large applicants will be discriminated against, and 2) high levels of underpricing indicates that outside investors hold smaller blocks. Brennan and Franks (1997) test these predictions using a sample of 69 firms going public in the U.K. in the period 1986-1989, and find evidence consistent with both; larger bids tend to be discriminated against, and they identify a negative relationship between the level of underpricing and the size of larger blocks. This is consistent with the management wanting to retain control, and the fact that underpricing is used as a method to obtain a dispersed ownership.

Field and Karpoff (2002) study anti-takeover mechanisms used by firms going public in the U.S., which is an alternative approach to retain control without the use of underpricing. They find that IPO shares are underpriced even when take-over defenses are in place. Thus, the desire to maintain control cannot explain the underpricing alone, but may still explain some of the underpricing.

Underpricing as a means to reduce agency costs

This theory assumes that underpricing can be used to reduce agency costs by allocating shares to large institutional investors, as they will conduct monitoring of the management. Stoughton and Zechner (1998) argue that if the managers are part-owners of the firm, the extraction of private benefits ultimately hurts themselves in the form of lower IPO proceeds and lower share value. Thus, if the managers value their stake in the firm higher than private benefits, increased monitoring may be desired. Investors require compensation for making a large and non-diversified investment, thus the issuer has to underprice the shares. Moreover, the discount needs to be high enough to attract an institution of considerable size in order to ensure effective monitoring.

2.4.5. Behavioral explanations

Behavioral theories claim that underpricing can be explained by irrational behavior and biases among the main IPO participants. This could be investors bidding the IPO share price beyond the true value of the shares, or that the issuers fail to have the underpricing reduced by the underwriters. There exist little empirical evidence supporting the behavioral theories, however, they influence the hypotheses we will test in the way that they can increase or reduce the level of underpricing. Thus, the most recognized behavioral explanations from the IPO literature will be discussed below.

Cascades

The theory of informational cascades was first introduced by Welch (1992), and is presented in the book-building versus fixed-price model by Benveniste and Busaba (1997). In short, Welch develops a model in which the offer shares are priced using fixed-price to provide an explanation for IPO underpricing without the presence of Rock's (1986) winner's curse. If investors make their investment decisions sequentially, they will attempt to judge the interest of others and further base their investment decision on bids of earlier investors rather than on their own information. If initial sales are successful, demand will snowball because later investors believe that earlier investors held favorable information. On the other hand, unsuccessful initial sales will lead to later investors abstaining from making bids, even if they sit on favorable information. The possibility of cascades makes the issuing firm afraid of setting the price a little too high in case it will lead to a negative cascade. Thus, underpricing should be observed even in the absence of information asymmetries.

Support of Welch's (1992) informational cascades is offered by Amihud, Hauser and Kirsh (2003), who find that most IPOs are either undersubscribed (negative cascade) or many times oversubscribed (positive cascade), with few cases in between.

Investor sentiment

As mentioned in the theory of “hot issue” markets, Ibbotson, Sindelar and Ritter (1988) argue that windows of opportunity occur in periods when investors are overly optimistic about new equity issues. The investor sentiment theory in relation with IPOs was first modeled by Ljungqvist, Singh

and Nanda (2006). The model assumes that some investors have overoptimistic beliefs about the firm going public, and the issuer tries to capture this excess value by timing their IPO to periods of high investor sentiment ("hot" periods). The best way the firm can capture the "surplus" is to avoid flooding the market with stock and rather restrict the supply. However, eventually the stock price will revert to fundamental value, and thus, the long-run returns of the IPO shares will be negative. This strategy is however hard to practice as it assumes constraints on short-sale, that the firm can price discriminate, and that no regulatory constraints apply to inventory holding. Thus, for the investor sentiment theory to be able to explain observed underpricing, one has to assume that the issuer follows the strategy discussed under price stabilization theory (i.e. first allocate stock to institutional investors who subsequently resell shares to sentiment investors). The institutional investors capture the excess value from sentiment investors by restricting the supply, but still require that the stock be underpriced due to the risk of holding inventory as the sentiment demand may disappear prematurely.

The investor sentiment theory gives rise to several empirical predictions. For example, subsequent to the offering, the stock is expected to underperform relative to both the offer price and the first-day price if the firm is going public in a "hot" market. Purnanandam and Swaminathan (2004) find that IPOs that are overvalued at the offer price yield high first-day returns, but revert to fair value in the long run, indicating that investors that initially invest in the IPO are optimistic and thus, the offer price can exceed fundamental value. Ofek and Richardson (2003) study the "dot-com bubble" of 1998-2000 ("hot issue" market) and find evidence in line with the model of Ljungqvist, Nanda and Singh (2006). When institutions sell IPO shares to retail investors on the first trading day, high returns are observed. Subsequently, reversals occurred when the bubble burst.

Lastly, the theory of investor sentiment can help reconcile the mixed evidence found in studies of underpricing. For instance, the model of Ljungqvist, Singh and Nanda (2006) supports the positive relationship between underwriter reputation and initial returns observed after the 1980s, but argue that the relation depends on the state of the market. Prestigious underwriters with larger market shares can induce regular investors to carry more inventories at the threat of punishment (e.g. exclusion from future offerings). Since underpricing is used as compensation to regulars for holding inventory, IPOs managed by reputable underwriters should be associated with more underpricing. Moreover, investor sentiment offers an additional explanation for the partial adjustment theory. Ljungqvist, Singh and Nanda (2006) predict that when the difference in opinion between rational and irrational (sentiment) investors increases, the offer price is adjusted upwards and the underpricing increases. Aggarwal and Conroy (2000) and Cornelli, Goldreich and Ljungqvist (2006) offer empirical evidence in support of this prediction.

Prospect theory and mental accounting

Loughran and Ritter (2002) claim that behavioral bias among the managers of the issuing firm can explain why issuers rarely get upset by leaving money on the table in IPOs. They state that issuers care more about their personal wealth change than maximizing IPO proceeds. Loughran and Ritter (2002) combine prospect theory with the notion of mental accounting proposed by Thaler (1980, 1985), and argue that in the context of going public, the issuer perceives the underpricing cost and the gross proceeds as a package deal instead of considering the opportunity cost of underpricing by itself. Thus, the issuer does not mind leaving money on the table as long there is a net increase in its personal wealth. Further, mental accounting can also explain the partial adjustment phenomenon. A partial upwards revision of offer price leads to an increase in the expected gross proceeds, even though full adjustment would have led to higher proceeds. Thus, the issuer experiences a wealth increase and does not care about the additional price discount. Moreover, the underwriter's choice of underpricing the shares seems irrational because fully raising the offer price would increase its revenues as well. However, the underwriter is indirectly compensated through reduced marketing costs (easier to find buyers) and higher commissions from investors eager to be allocated shares in hot IPOs.

Finally, Ljungqvist and Wilhelm (2005) study whether CEOs are satisfied with the performance of their underwriter, where satisfaction is measured by net change in wealth. The authors find that issuers tend to rehire the IPO underwriter in subsequent offerings if they are satisfied with the investment bank's performance. Underwriters gain from this behavioral bias as they can charge higher underwriting fees in secondary offerings. However, there may be other factors affecting the results, and there exists little empirical evidence in support of this theory.

3. Methodology and data

This section outlines the methodology and data used in our research. Firstly, we describe the structure of our thesis, which is followed by an introduction of the hypotheses that will be tested. Lastly, we describe how our data has been collected and how it has been processed to construct the variables needed for the regression analysis.

3.1. Structure of our analysis

The objective of our thesis is to investigate the underpricing phenomenon among Norwegian IPOs, and six hypotheses have been developed to test the selected variables' explanatory power on underpricing. Necessary data has been collected from the Oslo Stock Exchange, Yahoo Finance, Orbis, the firm's prospectus and NewsWeb, in order to construct the variables used to test our selected hypotheses. Subsequently, STATA and the ordinary least squares (OLS) were used to estimate the unknown coefficients in our cross-sectional study, by regressing the dependent variable (adjusted underpricing) on all the explanatory variables. The regression results enabled us to determine the relationship between underpricing and the selected variables, and their corresponding significance level. Robustness tests have been conducted to identify and deal with econometric issues. Based on our findings, we have been able to assess the explanatory power of each variable and drawn a conclusion about the various theories of underpricing in relation to the OSE. Hypotheses are ultimately rejected if the corresponding variable has a small coefficient and/or is statistically insignificant.

3.2. Hypotheses

There exist several theories of underpricing in the literature; however, we are only able to test a limited number due to restricted data access and time constraint. The fit to the Norwegian market, our own interest and the prevalence of the theories are additional factors that have influenced our choice of study.

Further, previous researchers have identified several patterns of high initial returns internationally; hence, the objective of our hypotheses is to identify whether investors are able to sort out the offerings that are more exposed to underpricing in Norway. The six hypotheses and the motivation behind them are briefly explained below.

Hypothesis 1:
On average, IPOs that are priced using the book-building mechanism experience less underpricing, compared to fixed-price offerings.

The hypothesis is motivated by the conventional wisdom in the literature. The majority of papers that compare the fixed-price method to book-building find that book-building is associated with less

underpricing on average (e.g. Benveniste and Wilhelm 1990; Spatt and Srivastava 1991; Benveniste and Busaba 1997; Biais and Faugeron-Crouzet 2002). The theoretical reasoning behind the hypothesis is that book-building reduces information asymmetries (i.e. mitigates the winner's curse) by inducing informed investors to reveal private information.

From the model of Benveniste and Busaba (1997), we found that in fixed-price offerings, the level of underpricing is determined by the full value of the private signal of the first investor in line. In comparison, the underpricing in book-building offerings is determined by the marginal value of investor signals. Thus, the underpricing required to create a positive cascade in a fixed-price offering is higher than the price discount that is necessary to elicit investor information in book-building.

However, some studies find that book-building is in fact associated with more underpricing than fixed-price offerings. For instance, Ljungqvist, Jenkinson and Wilhelm (2003) report that the fixed-price method dominates book-building in European IPOs. Thus, we do not rule out that we can identify the same relationship.

Hypothesis 2:
On average, IPOs conducted in periods of (high) market uncertainty, measured by market volatility prior to the listing, are associated with higher underpricing.

Ritter (1984) and Beatty and Ritter (1986) argue that the greater uncertainty prior to the IPO, the more underpricing should be observed. When the ex-ante uncertainty increases, the winner's curse intensifies, and uninformed investors require more underpricing to partake in the offering. Derrien and Womack (2003) document a strong positive relationship between market volatility and underpricing of French IPOs. The same positive relationship is identified in the U.S. market by Lowry, Officer and Schwert (2010) when using time-series return volatility. Thus, we hypothesize that the same relationship holds for the Norwegian IPO market.

However, Lowry, Officer and Schwert (2010) report that the relationship between volatility and initial returns of IPOs is weak when using cross-sectional return volatility, and Schill (2004) find that an increase in market volatility has no direct effect on IPO underpricing. Therefore, we may not be able to identify any relationship between the volatility of the Oslo Børs All-Share Index (hereafter referred to as OSEAX) and the underpricing of our sample IPOs.

Hypothesis 3:
IPOs that are conducted following an increase in the overall stock market are associated with higher underpricing.

Similar to the previous hypothesis, this hypothesis is motivated by the assumption that market movements prior to an IPO increase the uncertainty of the issue. Moreover, we hypothesize that Norwegian underwriters do not fully adjust the offer price to reflect movements in the OSEAX prior to an IPO. Hence, we expect to find the same positive relationship between stock market performance and underpricing in Norway as observed for French and U.S. IPOs by Derrien and Womack (2003) and Loughran and Ritter (2002), respectively.

Hypothesis 4:
On average, IPOs managed by a reputable underwriter are associated with less underpricing.

Firstly, the fact that we have 18 different lead underwriters in our sample of 88 IPOs indicates that the investment banking industry in Norway is highly competitive[2]. Therefore, the reputation of the lead investment bank is likely to be an important factor for issuers in the selection process (Abrahamson, Jenkinson, and Jones 2011).

The underwriter reputation hypothesis is motivated by the theory of prestigious underwriters having a certification-of-quality-role in IPOs. The issuer can hire a reputable underwriter to signal its low risk (high quality) to the public, thus reducing the information asymmetry between uninformed and informed investors. A reduction in asymmetric information mitigates the winner's curse, which entails less need for underpricing. Several empirical studies conducted using IPO samples from the 1980s identify a negative relationship between underwriter reputation and underpricing (McDonald and Fisher 1972; Logue 1973; Beatty and Ritter 1986; Tinic 1988; Carter and Manaster 1990; Carter, Dark and Singh 1998; Dunbar (2000).

Contrarily, using a sample of IPOs conducted after the 1980s, Beatty and Welch (1996) discover a reversal of the negative relationship, which is later supported by Loughran and Ritter (2004), and Liu and Ritter (2011). Liu and Ritter (2011) argue that the reversal is due to a change in the behavior of issuers in the 1990s. In the 1980s, issuers were more price sensitive, whereas in the 1990s, firms going public started to care more about underwriting services like industry expertise and analyst coverage. Assuming that issuers are willing to pay more for such services, prestigious underwriters should be associated with higher underpricing.

Due to the mixed empirical evidence, it is hard to predict if we will find a positive, negative or no significant relationship between underwriter reputation and underpricing in our sample. Fjesme (2015) discovers a positive sign of his top-tier dummy in his study of Norwegian IPO underpricing; however, the relationship is insignificant.

[2] A list of all lead underwriters can be found in appendix 2.2.

Moreover, no study has tested the relationship with an updated sample (the last year in the sample used by Liu and Ritter is 2008), and no one has yet supported the non-price dimension theory of Liu and Ritter (2011). Thus, we formulate our hypothesis based on the theory that has received the most empirical support, namely the certification theory, and hypothesize that underwriter reputation is negatively related to underpricing.

Hypothesis 5:
On average, there is observed higher underpricing among IPOs where the offer price has been revised up.

The motivation behind this hypothesis is primarily based on theories of information revelation and behavioral explanations. Hanley's (1993) partial adjustment theory suggests that underwriters facing a stronger demand for shares than anticipated do not fully adjust the offer price to meet the excess demand. The most acknowledged explanation for this partial adjustment is that the underwriter building a book needs to induce investors to reveal private information, and the investors require compensation for being truthful. Loughran and Ritter (2004) offer an alternative explanation based on behavioral theory, namely that issuers experiencing an unexpected increase in wealth (as a result of the upwards revision of offer price) are more likely to leave more money on the table. In contrast, if the offer price is revised down, issuers face a decrease in wealth, which should cause less underpricing.

Empirical evidence was first put forward by Hanley (1993), and has been corroborated by numerous studies, both in the U.S. and internationally. We want to test if the partial adjustment phenomenon is able to explain some of the underpricing observed in Norwegian IPOs, and we expect to find a positive relationship between the research variable and the level of underpricing.

Hypothesis 6:
On average, "hot issue" markets are subject to higher underpricing relative to "cold" and "neutral" periods.

The hypothesis is emphasized by the observed underpricing in "hot issue" markets, i.e. periods with high number of IPOs, high issue volumes and high initial returns, which was first introduced by Ibbotson and Jaffe (1975) and later confirmed by Ritter (1984) and Ibbotson, Sindelar and Ritter (1988). Previous studies have empirically identified more underpricing in periods of higher equity issue volumes in larger economies such as the U.S., China, Hong Kong (Güçbilmez 2015) and Germany (Günther and Rummer 2006). We want to investigate whether the "hot issue" characteristics also prevail in a smaller market like Norway.

3.3. Data selection

The sample selection process has been time consuming, but necessary in order to create the unique data set we need for testing our hypotheses. The initial dataset of IPOs was kindly provided by the Oslo Stock Exchange (email correspondence). The dataset contained 147 IPOs and private placements in connection with listings on OB and Oslo Axess between January 1, 2005 and December 31, 2015, with corresponding offer prices. A sample period of eleven years seems appropriate as we should be able to capture fluctuations in the economic activity and identify both "hot" and "cold issue" markets within this time period. Further, this period provides us with a sufficient number of IPOs for the scope of our research. If we had included IPOs prior 2005, we would most likely have had to exclude a relatively large number of offerings due to missing information and prospectus. This would in turn introduce some degree of survivorship bias in our sample, which we would like to avoid. An overview of the sample selection process is presented in Table 1.

	No. of IPOs
Initial dataset	**147**
Listed on Oslo Axess	46
Secondary offerings	6
Demergers	3
Missing information	4
Final sample	**88**

Table 1: The process of excluding IPOs.

Firstly, we excluded firms that were listed on Oslo Axess. As mentioned earlier, Oslo Axess is subject to less strict listing requirements than OB, and is better suited for smaller and younger companies. This in turn entails that the firms going public are associated with smaller IPO sizes and less liquid shares. If we included highly illiquid shares in our sample, the return calculations could be inaccurate due to large bid-ask-spreads. Further, we excluded issues that were not initial (e.g. firms trading on foreign exchanges at the time of the Norwegian listing, firms that have been taken off the exchange and then re-listed, etc.). The shares of these issuers are already priced, and secondary listings cannot be compared to initial public offerings where the share is priced for the first time. Among others, Questerre Energy Corporation and Petrobank Energy and Res. Ltd. were excluded as they both traded on the Toronto Stock exchange at the time of the listing. Next, demergers (i.e. firms coming from already listed companies) were excluded for much of the same reason. These firms have been a part of a listed company, thus their shares are to some extent already valued by the market. Due to this, three demergers have been excluded from the initial dataset. Lastly, four firms were excluded due to missing information that could not be recovered. These firms went public in 2005 and two of them are delisted today.

Our final sample consists of 88 firms, where 35 firms have conducted a private placement in connection with the listing on OB, 38 firms have carried out both a public and a private offering and 15 firms have only conducted a public offering[3]. Private placements are included in our sample due to their similarities with public offerings. Private placements target an individual or a small group of specific institutional investors; however, the intention is coinciding with that of a public offering, which is to raise additional capital (Oslo Børs 2014). The inclusion of private placements could affect our analysis in several ways. For instance, theories of asymmetric information assume that institutional investors are mostly informed. Thus, there would be no winner's curse in private placements, and the underpricing should be lower. To make sure that the inclusion of private placements does not significantly affect the results of our analysis, we compare the underpricing between private and public offerings. The average underpricing is lower for private than public offerings, 2.36 percent versus 3.20 percent; however the difference is not statistically significant; hence, we will conduct our analysis using the total sample of 88 firms[4].

For each firm, we collected the following information from the Oslo Stock Exchange (NewsWeb, oslobors.no) and individual prospectuses: First-day closing price, total number of outstanding shares at the time of the listing, GICS industry, identity of lead underwriter, offering method (book-building or fixed-price), gross proceeds from offering (new shares), price filing range, offer period (days between offer price was set and the date of the offering). Market data; historical prices from OSEAX (Oslo Børs All-Share Index) and total equity issued on OB per month between 2005 and 2015, was collected from oslobors.no.

From Yahoo Finance, we collected historical prices on industry indices (OSE10, OSE15, etc.); however, OSE45 was provided by the Oslo Stock Exchange (email correspondence), as historical prices back to January 2005 could not be found at Yahoo. Lastly, we collected the founding year of each firm from the Orbis database.

Errors in data

It is important to be aware of any sources of error that can cause bias in our empirical study. Errors in data concern possible issues with the types of data collected and how the data has been selected. It is highly important that the data is valid and that the source is reliable. Thus, we need to determine the reliability of our data sources, which further examines the validity of our empirical results.

Secondary data has been collected from the Oslo Stock Exchange, Orbis, NewsWeb, Yahoo Finance and individual prospectuses. These financial sources are considered credible as none of

[3] The full list of IPOs in our sample can be found in appendix 2.1.

[4] H0: diff = 0 against HA: diff ≠ 0 with 86 degrees of freedom and assuming equal variance (standard deviations of 0.08 and 0.087), we obtain a t-value of 0.4705, thus we cannot reject H0.

them have any incentive to misrepresent information, making the reliability of the data high. However, some bias may be present as it has been necessary to exclude some firms due to lack of information. Moreover, the data has been manually processed, and small errors might have occurred. Still, all the data is double checked by the authors to make sure that no mistakes are made, and we consider the possibility of such errors relatively small.

Due to the relatively small IPO sample, the results of our analysis can be affected by extreme observations and outliers. The small sample could make it harder to get significant coefficients in the regression analysis, which may prevent us from being able to confirm our hypotheses. With a larger sample size, it could be easier to obtain statistically significant variables from the regressions. We keep this in mind throughout the analysis in section 4.

3.4. Construction of variables

3.4.1. Dependent variable

The objective of our thesis is to investigate different theories of underpricing and whether they are applicable to the Norwegian IPO market. Underpricing can be measured as the difference between the first-day closing price and the offer price. However, the initial return has to be constructed as a comparable measure, as we are analyzing underpricing among different issues. Thus, we divide the initial return by the offer price of the share and multiply by 100 to get the percentage change from the offer price to the closing price in the secondary market. The following formula is used to estimate the simple initial return of the IPOs in our sample:

$$IR_i = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}}$$

IR_i: Initial return of stock "i"
$P_{i,t}$: First-day closing price of stock "i"
$P_{i,t-1}$: Offer price of stock "i"

The initial return formula is based on the assumption that there is no time gap between the date the offer price is set and the first-day of trading. However, the day the offer price is announced and the first trading day may differ; thus, we need to account for market movements that can have a substantial effect on the stock price during the subscription period. The average time gap in our sample is equal to four trading days; hence, we adjust the first-day return to make sure that the observed initial return is explained by underpricing (unbiased) rather than an increase or a decrease in a broader market index (biased). Market-adjusted underpricing is a commonly used measure in the IPO literature, and is supported by authors like Logue (1973), Ritter (1991), and Bansal and Khanna (2012).

$$MIR_i = IR_i - MR_i = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}} - \frac{I_{i,t} - I_{i,t-1}}{I_{i,t-1}}$$

MIR_i: Market-adjusted initial return of stock "i"
MR_i: Market (index) return on day "i"
$I_{i,t}$: Closing index at listing day "i"
$I_{i,t-1}$: Closing index at day "i" when the offer price is set

The formula above shows how the market-adjusted initial return is calculated. The choice of market index is important and should reflect the alternative investment of an investor subscribing to an IPO (Hunger 2016). Thus, choosing the wrong market index may result in a biased market-adjusted initial return. We have chosen to use the return of GICS industry indices to adjust the simple underpricing, and start by dividing our sample firms into their respective industry (e.g. KID is placed in consumer discretionary and Skandiabanken is placed in financials). Telecommunication is not included as we do not have any firms belonging to this industry. Next, we calculate the industry index return for each IPO as the difference between the index closing price at listing day and the index closing price at the day the offer price is set, relative to the closing price of the index at the day the price is set. Subsequently, the industry return is subtracted from the simple initial return of each firm to estimate the adjusted underpricing. We will use the market-adjusted underpricing as the dependent variable in our regression analysis, and the variable is named *UP*.

3.4.2. Explanatory variables

The explanatory variables include research variables, control variables, and year- and industry dummies. The research variables are used to test our hypotheses and will be the main focus of the regression analysis. Control variables and dummies are not of particular interest to our hypotheses, but we assume that these are related to underpricing. Thus, we will include them in the regression analysis to remove their effect.

In order to improve the fit of the regression model, we have used logarithmic transformation on the explanatory variables that appear to be highly skewed in their original form. Moreover, taking the natural logarithm makes the estimates less sensitive to extreme observations, which is preferable due to our small sample (Wooldridge 2009, 191). An explanation of how the variables have been constructed is provided below.

Research variables

In order to test our hypotheses, we create a total of six research variables, one for each hypothesis.

Book-building (BB): A book-building dummy has been constructed to test hypothesis 1, where we want to investigate if book-building is a more efficient pricing mechanism in Norway than fixed-price. The dummy variable takes the value 1 if the issuing firm used book-building in the IPO process and 0 if it used fixed-price.

Market uncertainty (VOL): In order to test if market uncertainty prior to an IPO is associated with higher initial returns, we use market volatility of the OSEAX as a proxy. We regressed three different measures of volatility on underpricing and chose to use the standard deviation of daily returns 21 trading days (1 month) prior to the IPO, as this measure seems to be the variable with the most economic influence (i.e. highest coefficient) and highest statistical significance (i.e. smallest p-value and largest R-squared). This is identical to the proxy used by Derrien and Womack (2003), and the variable is named *VOL*.

	VOL1M	VOL3M	VOL100D
Correlation	-5.99%	-2.45%	-5.27%
Coefficient	-1.1843	-0.0836	-0.1488
P-value	0.5793	0.8211	0.6256
R-squared	0.36%	0.06%	0.28%
Adj. R-squared	-0.80%	-1.10%	-0.88%

Table 2: Comparison between UP and different measures of volatility.

Market return (MRET): In order to test hypothesis 3, we construct a market return variable to proxy for the overall market performance prior to an IPO. The variable is created relatively similar to Derrien and Womack (2003). First, we compute buy-and-hold return of OSEAX for 1 month, 3 months and 100 days prior to each IPO in our sample[5]. Next, the returns are normalized (to monthly returns) and given individual weights based on the assumption of Derrien and Womack (2003); that investors care more about the return in recent periods. Hence, weight 1 is given to 100 days, 2 to 3 months, and the most recent month is given weight 3. Lastly, the return is divided by 6 to get the average weighted return.

To verify that the weighted market return is the most appropriate measure, we regress each of the four normalized market returns on underpricing. We observe that the correlation with underpricing and R-squared are about the same for the weighted return (RW), the 3 month return (R3M) and the return over 100 days (R100D). However, the coefficient of RW is double the size of the other coefficients, and we confirm that this is the most suitable proxy. The variable is named *MRET*.

[5] 1 month equals 21 trading days, 3 months equal 63 trading days, and 100 days equal 100 trading days.

	RW	R1M	R3M	R100D
Correlation	31.9%	26.0%	32.9%	33.0%
Coefficient	0.7817	0.3907	0.3498	0.3128
P-value	0.0025	0.00145	0.0017	0.0017
R-squared	10.16%	6.75%	10.83%	10.87%
Adj. R-squared	9.12%	5.66%	9.79%	9.83%

Table 3: Comparison between UP and different measures of market return.

Underwriter reputation (LN(REP)): In order to test hypothesis 4, we need to construct a proxy for underwriter reputation. Several measures can be used, and we start by computing two different variables and assess which one we will use. The first one, LN(REP_GP), is the Megginson and Weiss (1991) measure of underwriter quality, which is based on the amount of money brought to the market by the lead underwriter. For each IPO in the sample, we have identified the lead underwriter, who is "assigned" the gross proceeds of that IPO. Next, we calculate each investment bank's percentage of the total gross proceeds in the sample. This individual market share is the measure of underwriter quality, and we assume that the greater the market share, the greater the quality of the investment bank. In 16 of the IPOs, there were two lead underwriters. In these cases, we use the average market share of the two underwriters as a measure of underwriter prestige. The second variable for underwriter reputation, LN(REP_NUM), is based on the number of IPOs in which the investment bank acted as the lead underwriter. The market share of each underwriter is found by dividing the number of IPOs of one bank on the total number of IPOs. In the IPOs with two lead underwriters, each is assigned 0.5 IPO[6].

	LN(REP_GP)	LN(REP_NUM)
Correlation	0.1003	0.0629
Coefficient	0.1179	0.0975
P-value	0.3524	0.5604
R-squared	1.01%	0.40%
Adj. R-squared	-0.14%	-0.76%

Table 4: Comparison between UP and different measures of underwriter reputation.

After comparing the two measures, we can see that LN(REP_GP) has a larger coefficient, a higher correlation and a higher adjusted R-squared. Additionally, LN(REP_GP) is more significant than LN(REP_NUM). Hence, we use LN(REP_GP) as a proxy for underwriter reputation, and name it *LN(REP)*[7].

[6] We assume that the underwriters' market shares do not change over the sample period.

[7] An overview of all the underwriters and their rank can be found in appendix 2.2.

Revision of the offer price (REV): In order to test if the partial adjustment of offer price (hypothesis 5) can explain average underpricing in Norway, we construct a variable that measures the revision of offer price. The variable is calculated as the percentage difference between the midpoint of the original price range listed in the prospectus, and the offer price at which the shares are sold. The reason why we use this measure and not a "revised up" dummy is that our sample includes only 3 IPOs in which the price has been revised above the maximum price in the original range. Furthermore, 11 firms have revised the price down (below the minimum in the price range). The downward revision will be captured in the REV variable as it can take on negative values, which is not the case for a dummy variable.

"Hot issue" (HOT): A "hot issue" dummy is included to test hypothesis 6; whether going public in a "hot issue" market is associated with more underpricing than going public in a "cold/neutral" market. The HOT dummy takes the value of 1 for "hot issue" periods and zero otherwise ("cold" or "neutral" periods).

To identify "hot" periods, we start by calculating total equity issued on OB every month from the beginning of 2005 to the end of 2015. Next, months are defined as "hot" if the monthly issue volume is in the 90th percentile of the total volume or if two consecutive months are both in the 80th percentile. The graph below illustrates the choice of "hot" periods, and also shows the periods defined as "cold" (25th percentile for one month or 40th percentile in two consecutive months). The remaining months are defined as "neutral".

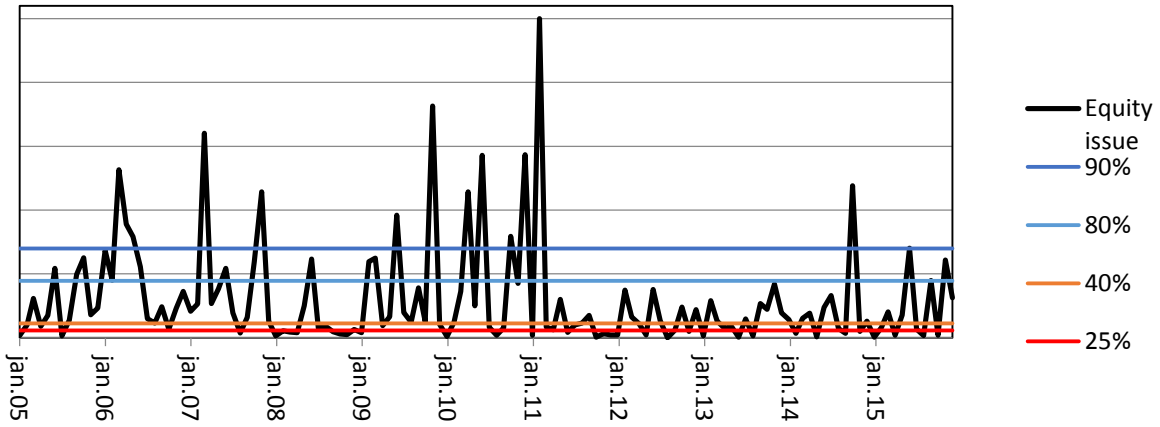

Figure 5: Monthly equity issued on OB in the period 2005-2015. Source: Adapted from Oslo Børs (2016j).

Control variables

Control variables are included in a regression to isolate the causal effect of a certain variable (Wooldridge 2009, 98). We have included three control variables in our regressions to account for ex-ante uncertainty. The distribution of age, market capitalization, and gross proceeds are highly

skewed, thus we take the natural logarithm of all three control variables. The variables are not the primary interest of our research, and are therefore only shortly described below.

Size (LN(MCAP)): Market capitalization has been used as a proxy to control for company size. The variable is calculated as the offer price times the total number of outstanding shares at the time of the IPO (not including the possible over-allotment option).

Age (LN(AGE)): Age is included to control for how established the firm is. Age is measured in full years from the year the company was founded to the year it was listed.

Gross proceeds (LN(GP)): To control for issue size, we have used gross proceeds. The control variable is calculated as new shares issued times the offer price.

Industry- and year dummies

We construct industry dummies based on GICS-codes to account for the industry specific effects, such as variation in ex-ante uncertainty, observed by Ibbotson and Jaffe (1975) and Ritter (1984). Telecommunications (OSE50) is not included as we do not have any observations within this industry. Similarly, the utilities sector (OSE55) is excluded to avoid perfect multicollinearity. Year dummies are included to control for the unexplained and known time variation in underpricing (Ljungqvist, Jenkinson and Wilhelm 2003). However, year 2008 is excluded as no firms went public this year, and 2015 is omitted to avoid perfect multicollinearity.

4. Analysis and results

This section provides an overview of descriptive statistics, where we analyze and interpret the relationship between some of our variables and the average underpricing. The results are further linked to the relevant theories and previous findings in the IPO literature. Subsequently, we run three regressions; the first including our six research variables, the second containing the six research variables and the three control variables, and the third including additional year- and industry dummies. Further, econometric issues are presented and our results are corrected for problems that may be present in our models. The results from each regression are further discussed and compared to previous findings. Lastly, we provide a summary of our results and an overview of which hypotheses that are supported in the Norwegian market.

4.1. Descriptive statistics

Underpricing

Firstly, the estimated simple underpricing is compared to the adjusted underpricing, and the summary statistics are presented to examine the distribution of our dependent variable.

	Simple underpricing	Adjusted underpricing
Mean	3.03%	2.87%
Median	0.11%	0.34%
Standard Deviation	8.50%	8.22%
Sample Variance	0.72%	0.68%
Kurtosis	3.008	2.347
Skewness	1.485	1.444
Minimum	-15.67%	-13.94%
Maximum	31.21%	28.63%
No. positive or zero return	56	44
No. negative return	32	44
No. IPOs	88	88

Table 5: Summary statistics of simple and adjusted underpricing.

The average simple underpricing is estimated to 3.03 percent. After adjusting for movements in industry indices, the initial return is reduced to 2.87 percent. The lower adjusted return indicates that industry return for the total sample was positive, on average. We will move forward using the market-adjusted initial return in line with e.g. Logue (1973), Ibbotson and Jaffe (1975), and Loughran, Ritter and Rydqvist (2015).

A simple t-test shows that the average adjusted underpricing is statistically different from zero. With a t-value of 3.27, underpricing is significant at the 1 percent level. The 95 percent confidence interval ranges from 1.12 to 4.61 percent. Consequently, we can confirm the existence of IPO

underpricing of Norwegian IPOs in the period between 2005 and 2015[8]. However, the initial return is lower than the one previously observed in Norway. Recall that between 1984 and 1996, the average initial return was 12.5 percent. In the period 1993-2007, the observed first-day return was 9.99 percent, and in the period 2000-2006, the simple underpricing was found to be 4.33 percent. Finally, using information collected from several sources, Loughran, Ritter and Rydqvist (2015) report an average underpricing of 8.1 percent between 1984 and 2013. Thus, the initial return appears to be decreasing over the time period, which could explain why we find an even lower return than previously observed.

The descriptive statistics of our sample are in line with Ibbotson (1975), who finds that the distribution of initial returns is positively skewed, with a positive mean and a median close to zero. We have an equal number of overpriced and underpriced IPOs, thus the positive mean and median indicate that our sample is skewed to the right. Compared to a normal distribution with skewness of zero and kurtosis of three, our sample has a skewness of 1.444 and kurtosis of 2.347. The distribution of our sample is illustrated below.

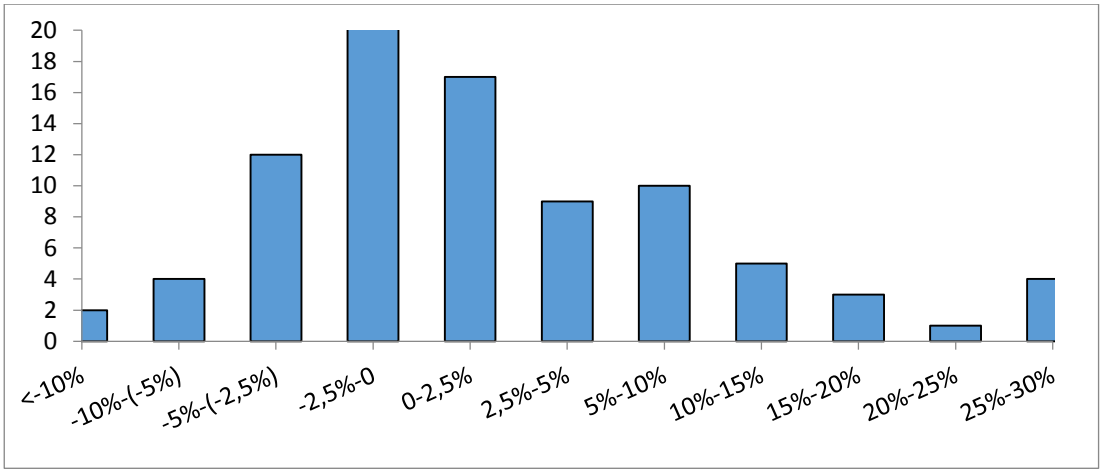

Figure 6: Distribution of initial returns in our sample.

We observe that the distribution has a long right tail, which was expected from the positive skewness. This indicates that the positive returns are larger relative to the negative returns. Moreover, the distribution is slightly flatter (and wider) than the normal distribution, confirmed by the kurtosis below three. Consequently, our observations of initial returns do not appear to be normally distributed. The fact that our dependent variable is non-normally distributed is most likely not an issue due to our sample size, but we perform a Wilcoxon signed-rank test to confirm the significance of underpricing. This is a nonparametric test procedure that does not rely on the normality assumption (Gibbons 1993). With a z-value of 2.153, we can reject that the average

[8] Two-sided test against H0: mean = 0, with 87 degrees of freedom returns a t-value of 3.27.

underpricing is zero at the 5 percent level, and confirm the existence of underpricing in Norwegian IPOs.

Further, we would like study the relationship between ex-ante uncertainty related to an IPO and underpricing. As mentioned in the theory part, uncertainty can be observed in industry differences, market condition, age and size, and we start by examining the relationship between underpricing and industries.

Industry differences

By categorizing our sample in accordance to GICS sectors, we can study the differences in the level of underpricing between industries.

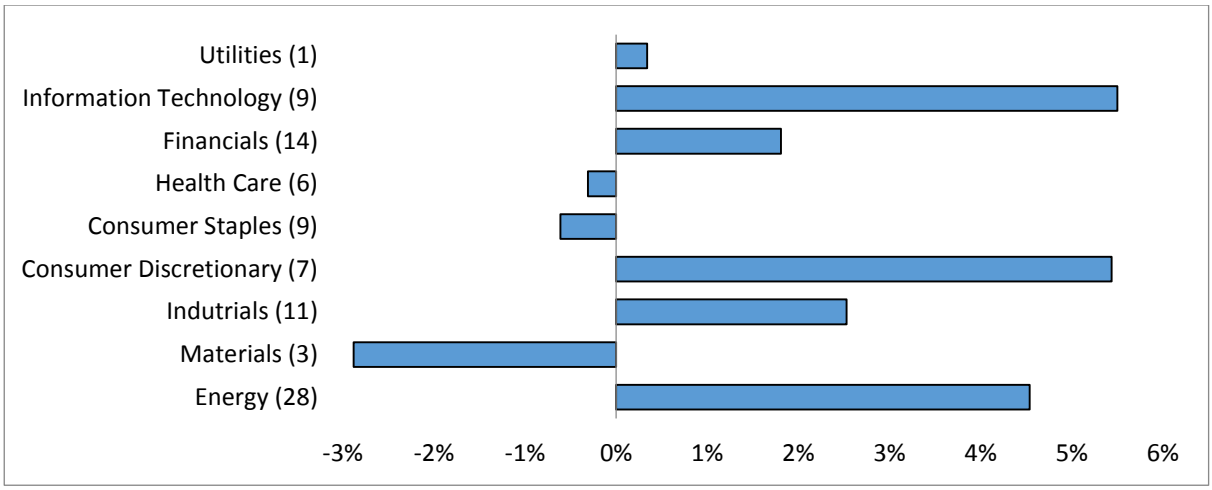

Figure 7: Industry differences in initial returns. The number inside the parentheses are the number of IPOs in each sector.

Risk compensation theory suggests that high-tech IPOs are harder to value than non-high-tech firms, and thus should be associated with more underpricing. Without any telecom IPOs, our 9 high-tech offerings can be found in the IT sector. In line with the findings in Loughran and Ritter (2002), we observe that the IT industry is subject to the highest average underpricing of 5.5 percent. Further, we find consumer discretionary to be the second most underpriced industry with an initial return of 5.44 percent. This is supported by Henrick (2012), who finds that consumer services are subject to higher underpricing due to an added risk premium. According to Eraydin (2008), financials should be associated with higher initial returns. We can confirm underpricing among financial IPOs; however, the underpricing is lower than for several of the other industries. Lastly, we observe that the materials sector is associated with the highest overpricing (-2.88%). This can be explained by the fact that this is a traditional industry facing low uncertainty, or it could be due to few firms in the industry. Only three of our firms are placed in this industry, and two of them are

overpriced. Next, we consider the relationship between the return and volatility of the OSEAX, and IPO activity in the Norwegian market.

IPO activity and market condition

We start by investigating the relationship between number of IPOs and the general market condition to try and identify "hot" and or "cold issue" periods in the sample period. Thus, we link the number of IPOs each year to the overall performance and uncertainty of the OSEAX. It should be mentioned that the measures of volatility, market return and IPO activity are simplifications of the variables used in the regression model. Here, we use yearly measures of activity, volatility and market return for illustrative purposes[9].

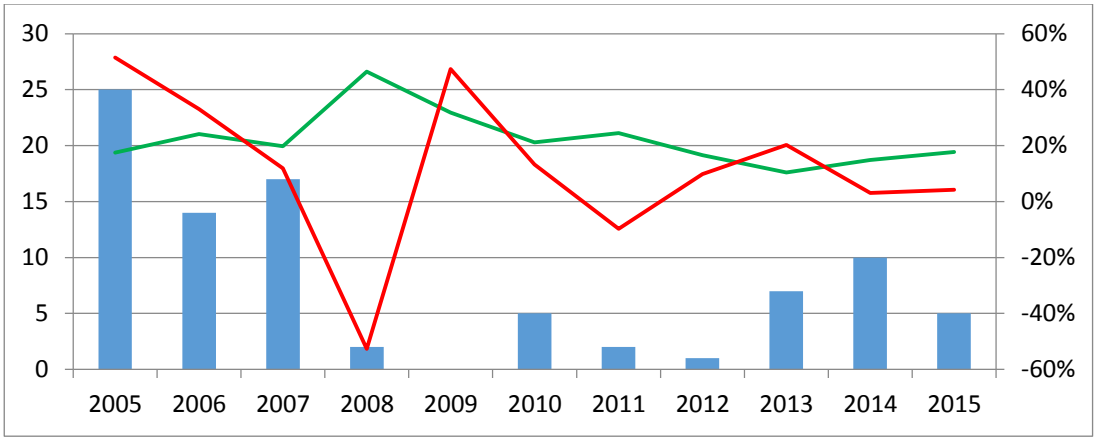

Figure 8: Number of IPOs each year (blue), annual market returns (red line) and volatility (green line) of the OSEAX. Source: Adapted from Oslo Børs (2016k).

The number of IPOs per year ranges from 0 in 2009 to 25 in 2005. The low IPO activity observed in the period following 2008 could indicate a "cold issue" period, and may be explained by the aftermath of the financial crisis in 2008. The red line represents the one-year buy-and-hold return of the OSEAX. We observe a positive correlation between the overall market performance and the IPO activity, with the exception of the high return identified in year 2009 where we have no observations. Hence, the relationship is challenged by the fact that we observe the second largest market return in a year where we have no IPOs, which is the opposite of what we expect. The pairwise correlation between market return and the number of IPOs is 0.47[10].

The majority of the IPOs occurred between 2005 and 2007 when 56 firms, representing about 64 percent of our sample, went public. The market return during these years was 32 percent on average, and may imply a "hot issue" period in the Norwegian IPO market. On the other hand, in

[9] The table reporting annual return, volatility, number of IPOs and underpricing can be found in appendix 3.1.
[10] Correlation matrix can be found in appendix 3.2.

the years 2008 and 2011 we observe a declining market with market returns of -52.61 and 9.73 percent, respectively. Only two firms went public these years, which may indicate a "cold issue" period. The positive relationship between market return and IPO activity is consistent with the theory of issuers taking advantage of windows of opportunity, which leads to a clustering of IPOs in periods of high investor optimism (Ibbotson, Sindelar and Ritter 1988). The finding is also in line with the IPO activity observed by Ritter and Welch (2002) in periods of high market return (internet bubble).

Lastly, the green line represents the annualized standard deviations of the daily OSEAX returns. We observe a negative correlation coefficient of -0.35 between volatility and IPO activity, and the "cold" years (2008 and 2011) are among the years with the highest volatility. This relationship is the opposite of what we expect from the risk compensation theory and the theory of "hot issue" markets. Higher volatility should increase the ex-ante uncertainty and be associated with more underpricing. On the contrary, "cold issue" periods should be associated with less underpricing than "hot". Consequently, both these relationships cannot hold if the volatility is high in "cold" periods.

"Hot issue" markets and underpricing

We hypothesize that there should be a positive relationship between IPO activity and the average initial return. Moreover, a favorable market condition prior to an IPO is expected to be positively related to underpricing. Based on the return and volatility of the OSEAX, we have identified a possible "hot issue" market between 2005 and 2007, and two possible "cold" years in 2008 and 2011. We expect to observe more underpricing in "hot" years than in "cold", and the relationship is illustrated below.

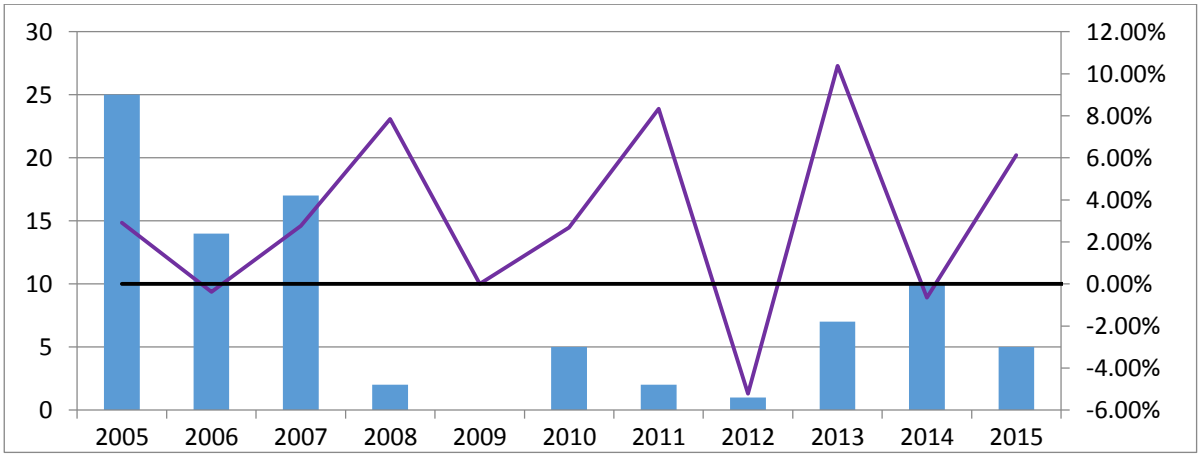

Figure 9: Comparison between number of IPOs each year (blue) and annual average underpricing (purple line) in our sample. The underpricing in 2009 is set to zero for illustration purposes; however, there are no IPOs this year and thus no underpricing.

The average underpricing in our sample ranges from -5.22 percent to 10.37 percent and we observe no distinct relationship when comparing the number of firms going public to the average underpricing. The initial return fluctuates with the number of IPOs in the 2-3 years prior to the financial crises, before it reaches 7.85 percent in 2008. The initial returns prior to 2008 are however not abnormally high as one would expect in a "hot issue" market. Thus, the possibility of a "hot issue" period between 2005 and 2007/2008 observed in the previous graph of market return and IPO activity is not supported by the level of underpricing. Moreover, the "cold issue" years of 2008 and 2011 are the years associated with some of the highest levels of underpricing, and thus the relationship between "hot issue" periods and underpricing cannot be confirmed.

In sum, the "hot issue" periods identified by number of IPOs and market condition are not associated with higher initial returns. If we were to define "hot" and "cold" periods based on initial returns (Ibbotson 1975), we would argue that 2008, 2011 and 2013 are "hot" years, while 2006, 2012 and 2014 could be defined as "cold" years (overpricing of IPOs). However, this contradiction can be due to the simplification of using annual measures. As previously mentioned, Derrien and Womack (2003) claim that investors care most about recent market movements, thus the market return and volatility observed up to a year prior to the IPO may not be of great concern to the IPO participants. Moreover, the variation in underpricing levels observed in our sample may not be large enough to constitute neither "hot" nor "cold issue" periods. The fluctuations in initial returns are not even close to the fluctuations observed by Ritter and Welch (2002) during the internet bubble in the U.S., where the underpricing first increased from around 10 percent prior to the bubble, before it peaked at 65 percent in 2000, and then dropped to 14 percent in 2001. In our sample, the greatest fluctuations occur between 2011 and 2013 with a drop from 8.34 percent to -5.22, and then an increase to 10.37 percent. Further, the low number of IPOs in this period (e.g. only one IPO in 2012) makes the underpricing measure more company-specific and does not assess the link between market "hotness" and average underpricing. As a consequence, a different measure than number of IPOs and market condition will be used to identify "hot" periods when we statistically test the relationship between "hot issue" markets and average underpricing. We have found total equity issue volume on OB to be a more appropriate proxy for "hot issue" periods, and we investigate whether this pattern can explain some of the observed underpricing among Norwegian IPOs.

Age

Age and size act as control variables in the regression, but we would like to check if the theoretical prediction of more established firms being associated with less underpricing is apparent in our sample. Gross proceeds are not examined as this variable is closely related to firm size.

The age of firms going public in our sample varies from 0 to 169 years, with a mean of 21.7 and a median of 10.5. The distribution of age and the corresponding underpricing is illustrated below.

Age	No. Firms	No. Underpriced	Underpricing
<5	22	16	4.6 %
5-20	49	23	2.5 %
21-50	8	3	-0.8 %
>50	9	7	3.7 %

Table 6: Comparison between age and underpricing.

As mentioned under risk compensation theory, younger firms are associated with a greater deal of value uncertainty compared to older and more established firms, and should therefore be associated with more underpricing. A quarter of our sample firms went public with less than 5 years of operating history, and the majority of them are underpriced. The average underpricing of the youngest group is estimated to 4.6 percent, which is higher than for older firms, and confirms that younger firms are associated with more uncertainty and thus more underpricing in Norway. Moreover, in line with risk compensation theory, the level of underpricing decreases with age for the next two groups. The second group illustrates that the majority of the firms in our sample went public between the age of 5 and 20, and we observe that less than half of these IPOs are underpriced.

However, firms with more than 50 years of operating history at the time of the listing are associated with a relatively high level of underpricing. This is the opposite of what we expect, and may be explained by the large effect each firm is given due to the small category of nine firms. If we combine the firms with age equal to or above 21 years, the average underpricing is estimated to 1.5 percent; hence, it appears that underpricing is decreasing in age.

Size

The size of our sample firms going public, measured by market capitalization at the time of the listing, ranges from MNOK 43 to BNOK 46.9, with a mean of BNOK 3 and a median of BNOK 1.3. The distribution is illustrated below.

MCAP billions	No. Firms	No. Underpriced	Underpricing
<0.5	19	13	5.2 %
0.5-1	16	7	1.9 %
1-5	39	20	1.8 %
>5	14	9	3.6 %

Table 7: Comparison between size (market capitalization in BNOK) and underpricing.

Similar to age, size should be negatively related to underpricing according to the risk compensation theory. Larger firms are generally more established and there should be less uncertainty regarding their value.

We observe that in the smallest group (market cap below MNOK 500), the majority of firms are underpriced and the average initial return is 5.2 percent. The average underpricing is substantially lower for the two next groups, which is consistent with the theory of larger firms being associated with less ex-ante uncertainty.

However, similar to what we observed for age, we find that the group of firms with market capitalization above BNOK 5 is associated with both a higher initial return and a larger fraction of underpriced IPOs than the groups of firms with medium size. Again, this could be due to the effect one extreme observation can have on the average underpricing. For instance, REC Silicon experienced a first-day return of 24 percent, which has a large impact on the average of the group. By excluding this observation, the average underpricing for the largest group of firms decreases to 2.04 percent.

4.2. Regression models and interpretation of results

In this part, we present a summary of the variables constructed for testing our hypotheses and include the sign that we expect to find in the regression analysis. Next, we present the regression models and a table containing the output from our three regressions. We comment on the regression coefficients and their economical and statistical significance, and link our findings to previous research. Lastly, we address the hypotheses and discuss whether we can confirm that existing theories of underpricing can explain some of the observed high initial returns in Norwegian IPOs.

4.2.1. Regression variables

The table below presents the descriptive statistic of our regression variables.

Variables	Expected sign	Mean	Std. dev	Min	Max	No. obs
Dependent variable						
UP		2.87 %	8.22 %	-13.94 %	28.63 %	88
Research variables						
BB	÷	0.7955	0.4057	0	1	88
VOL	+	1.09 %	0.42 %	0.42 %	2.39 %	88
MRET	+	1.94 %	3.35 %	-9.47 %	8.16 %	88
LN(REP)	÷	10.19 %	7.00 %	0.04 %	21.59 %	88
REV	+	-2.19 %	11.55 %	-40.63 %	45.95 %	88
HOT	+	0.2614	0.4419	0	1	88
Control variables						
LN(GP)	÷	19.46	1.67	15.61	23.1	88
LN(MCAP)	÷	7.19	1.24	3.77	10.76	88
LN(AGE)	÷	2.37	1.23	0	5.14	88
		Year dummies			**Industry dummies**	
		Y2005			OSE10	
		Y2006			OSE15	
		Y2007			OSE20	
		Y2008			OSE25	
		Y2010			OSE30	
		Y2011			OSE35	
		Y2012			OSE40	
		Y2013			OSE45	
		Y2014				

Table 8: Descriptive statistics of regression variables.

4.2.2. Regression model and output

The three regressions we estimate are the following:

1) *Research variables:*

$$UP = \beta_0 + \gamma_0\, BB + \beta_1\, VOL + \beta_2\, MRET + \beta_3\, LN(REP) + \beta_4\, REV + \gamma_1\, HOT + \mu$$

2) *Research and control variables:*

$$UP = \beta_0 + \gamma_0\, BB + \beta_1\, VOL + \beta_2\, MRET + \beta_3\, LN(REP) + \beta_4\, REV + \gamma_1\, HOT + \beta_5\, LN(MCAP) + \beta_6\, LN(AGE) + \beta_7 LN(GP) + \mu$$

3) Research, control, and year- and industry dummies:

$$UP = \beta_0 + \gamma_0\, BB + \beta_1\, VOL + \beta_2\, MRET + \beta_3\, LN(REP) + \beta_4\, REV + \gamma_1\, HOT + \beta_5\, LN(MCAP) + \beta_6\, LN(AGE) + \beta_7 LN(GP) + \gamma_2\, Y2005 - \gamma_{10} Y2014 + \gamma_{11}\, OSE10 - \gamma_{18} OSE45 + \mu$$

The results from the three regressions can be summarized in the following table.

Variables	**Regular standard errors**			**Robust standard errors**		
Regression	(1)	(2)	(3)	(1)	(2)	(3)
Intercept	2.4923	8.4281	3.8869			
	(0.76)	(0.59)	(0.18)	(0.77)	(0.64)	(0.18)
BB	-3.0142	-2.5784	-2.8992			
	(-1.38)	(-0.94)	(-0.92)	(-1.03)	(-0.78)	(-0.80)
VOL	-0.2379	-0.5319	0.2099			
	(-0.11)	(-0.24)	(0.07)	(-0.13)	(-0.29)	(0.06)
MRET	0.7153	0.6577	0.6514			
	(2.65)***	(2.33)**	(1.49)	(2.76)***	(2.43)**	(1.59)
LN(REP)	0.1422	0.1622	0.1132			
	(1.11)	(1.23)	(0.72)	(0.86)	(0.94)	(0.61)
REV	0.1308	0.1542	0.1811			
	(1.78)*	(1.91)*	(1.83)*	(2.08)**	(2.21)**	(2.02)**
HOT	1.8239	2.2062	1.1296			
	(0.89)	(1.02)	(0.4)	(0.98)	(1.17)	(0.45)
LN(MCAP)		-0.7185	-0.9645			
		(-0.69)	(-0.78)		(-0.86)	(-0.87)
LN(AGE)		0.0087	0.5602			
		(0.01)	(0.61)		(0.01)	(0.74)
LN(GP)		-0.0493	0.5024			
		(-0.05)	(0.42)		(-0.06)	(0.42)
Year dummies	NO	NO	YES	NO	NO	YES
Industry dummies	NO	NO	YES	NO	NO	YES
R-squared	17.8%	18.8%	30.78 %			
Adj. R-squared	11.7%	9.4%	1.28 %			
F-value	(2.93)**	(2.01)**	(1.04)			

Table 9: The table shows the OLS coefficients obtained in the three regressions with the t-statistics reported in the parentheses. White heteroskedasticity-consistent t-statistics are in parentheses on the right hand side. The variables that are originally measured in percent (UP, VOL, MRET, LN(REP) and REV) are multiplied by 100 to make the output easier to interpret. The symbols ∗ (and respectively ∗∗, ∗∗∗) indicate significance at a 10% level (and respectively at a 5% level and at a 1% level). The full regression output can be found in appendix 3.3-3.5.

4.2.3. Research variables

Firstly, the intercept has a coefficient of 2.49 (percent), and can be interpreted as the average underpricing if all explanatory variables are zero. Due to the two dummy variables included, our intercept would reflect the effect of both "cold/neutral issue" periods and fixed-price offerings. However, the constant is not statistically significant, meaning that we cannot claim that the average underpricing is different from zero when all independent variables are zero.

Second, we observe that BB, MRET, REV and HOT all have the expected sign of the coefficients, while VOL and LN(REP) have the opposite sign of what we anticipated. The coefficient of VOL is -0.24, which indicates that a 1 percent increase in volatility in the month prior to an IPO is associated with 0.24 percent lower initial return, holding other variables constant. Relative to the average underpricing of 2.87 percent, the economic significance of volatility is quite small. Further, the negative sign is the opposite of what is predicted by the theory and empirically supported by several authors. Derrien and Womack (2003), Loughran and Ritter (2002), Lowry and Schwert (2002) and Lowry, Officer and Schwert (2010) all confirm a positive relationship between ex-ante volatility and underpricing. However, the coefficient is not significantly different from zero, and the wide 95 percent confidence interval (-3.89, 3.42) does not rule out that volatility could have a positive effect on the level of underpricing. The lack of individual significance of VOL indicates that volatility prior to an IPO is not a factor that can explain underpricing of Norwegian IPOs, which is consistent with the findings of Schill (2004).

Underwriter reputation has a coefficient of 0.142, which indicates that if the lead underwriter's market share increases by 10 percent, the IPOs managed by that underwriter is associated with 1.42 percent higher underpricing, holding other variables constant. This contradicts our hypothesis which states that more prestigious underwriters should be associated with less underpricing. However, this is the hypothesis we were most uncertain about, as Beatty and Welch (1996), Loughran and Ritter (2004) and Liu and Ritter (2011) find that the relationship became positive in 1990s, and no study has reported that the relationship has reversed back to being negative in the subsequent period. Consequently, our finding is in line with the theory of local underwriter oligopolies; that the issuers are less price sensitive than before and instead care more about the additional services provided by reputable underwriters. Moreover, Fjesme (2015) identify the same positive relationship between underwriter reputations, proxied by a top-tier dummy, and underpricing of Norwegian IPOs. However, in line with Fjesme (2015) we find that the coefficient is not statistically significant.

The negative book-building coefficient suggests that book-building is a more efficient pricing mechanism than fixed-price. This is consistent with the theoretical model of Benveniste and Busaba (1997). The HOT dummy has a positive coefficient, which indicates that IPOs conducted in "hot issue" markets are associated with higher underpricing than IPOs conducted in "cold" or "neutral issue" periods. This is supported by Ibbotson and Jaffe (1975), Ritter (1984) and Ibbotson, Sindelar

and Ritter (1988), although their measure of "hot issue" markets differ from ours. Nevertheless, neither the book-building variable nor the HOT dummy is statistically significant.

In fact, the only individually significant variables in our regression are MRET and REV. The coefficient of market return is relatively large and indicates that a 1 percent increase in the OSEAX prior to an IPO leads to 0.715 percent more underpricing (holding other variables constant). If we compare this to the average underpricing of 2.87 percent and note that market return ranges between -9.5 percent and 8 percent, this variable seems to have a large economic significance in our model. Our finding is in line with the risk compensation theory where an increase in ex-ante uncertainty results in higher underpricing, which is confirmed by Derrien and Womack (2003), Loughran and Ritter (2002), Lowry and Schwert (2002), and Lowry, Officer and Schwert (2010). With a t-value of 2.76, the coefficient is highly significant at the 1 percent level.

The coefficient of REV suggests that if the offer price has been revised up by 10 percent, underpricing is expected to increase by 1.31 percent. This finding is in line with the partial adjustment theory of Hanley (1993), and suggests that Norwegian underwriters do not fully adjust the offer price to reflect the excess demand of shares. The t-value of 2.08 indicates that revision of offer price is significant at the 5 percent (with robust standard errors).

Overall the model has an F-value of 2.93, suggesting that despite the fact that only two of our variables are individually significant, the variables are jointly significant at the 5 percent level. The R-squared of 0.1781 indicates that our first regression model explains about 18 percent of the sample variation in underpricing. This is relatively low, and indicates that the error term still contains most of the unexplained variation. Consequently, we include three control variables in the next regression model in an attempt to capture some of the unexplained variation.

4.2.4. Research and control variables

Control variables are added in order to better assess the relationship between our research variables and underpricing, and to avoid omitting any variables that belong in the model. The control variables for issue size and firm size both reveal negative coefficients, while age has a positive, but insignificantly small coefficient. Thus, larger firms and firms with larger issues are associated with less underpricing, which is what we expected based on theories of risk compensation and previous empirical findings. The age of firms going public seem to have no economic significance in explaining underpricing in Norway. Moreover, none of the control variables are statistically significant on an individual basis; however, the F-value of the model is 2.01, which implies that the variables are still jointly significant at the 5 percent level.

The inclusion of control variables does not have a big impact on the research variables. MRET and REV are still individually significant (both at the 5 percent level). Moreover, the coefficients on the

research variables are similar to the previous regression, except for VOL, which has doubled in size. Now, a 1 percent increase in volatility prior to an IPO is associated with a 0.532 percent higher initial return. Nevertheless, the coefficient remains insignificant and the confidence interval is still extremely wide. Lastly, there has not been any significant improvement in the R-squared, suggesting that the added variables explain a minimal fraction of the sample variation in underpricing. The adjusted R-squared is naturally lower because it imposes a penalty for adding additional explanatory variables.

4.2.5. Research, control and year- and industry dummies

Lastly, we add year- and industry dummies to control for time trends and industry-specific factors. Controlling for year- and industry-effects causes a reversal in the sign of VOL. The coefficient is now positive, which is in line with our hypothesis of ex-ante uncertainty leading to more underpricing. Now, a 1 percent increase in market volatility prior to an IPO is associated with 0.21 percent *higher* underpricing. However, the coefficient is still not significant, and the (95 percent) confidence interval is even wider than in the previous regressions (-6.92, 7.34), suggesting that we cannot conclude with there being any direct relationship between ex-ante volatility and underpricing in the Norwegian IPO market.

Another variable that changes sign is LN(GP), indicating that an increase in issue size results in higher initial return. The coefficient is however small and statistically insignificant. Moreover, the coefficients on HOT and LN(REP) decreases in size, while the coefficient of REV increases, suggesting that these research variables are correlated with one or more of the year- and industry dummies.

Lastly, the year- and industry dummies affect the statistical inference and the goodness-of-fit of our model. With a t-value of 1.59, market return is no longer significant (neither with regular nor robust standard errors). The overall F-value of the model is now 1.04, suggesting that the variables are jointly insignificant. However, the R-squared is substantially larger, and the regression variables can now explain about 31 percent of the sample variation in underpricing. Nonetheless, it is important to note that the R-squared can only increase when additional explanatory variables are added, and never decreases. Consequently, it is a poor tool for deciding if we should add one or more independent variables to our regression model, and we should be cautious when interpreting the improvement in goodness-of-fit when we add new variables (Wooldridge 2009, 88). Lastly, the consistently low R-squared in our model can be due to the general difficulty in predicting the dependent variable. Beatty and Welch (1996) argue that the poor goodness-of-fit can be explained by the fact that underpricing is hard to predict.

4.3. Econometric issues

To identify and solve possible econometric issues, we have performed several tests related to our regression analysis. Tests are done for all three regressions, but we will only report inference for tests on regression (2), as the conclusions from the hypotheses testing is identical in each case. The full tests with output can be found in appendix 4.

4.3.1. Functional form misspecification

To make sure that we have not omitted any explanatory variable that is a function of an explanatory variable included in the model (e.g. the squared or cubed), we perform a RESET test for misspecification. We perform the test both manually by regressing UP on the explanatory variables including the squared and cubed of the fitted values, and with the built-in STATA command "ovtest". The manual and automatic tests yield p-values of 0.1291 and 0.1601, respectively. Thus, we cannot reject the null, and the model is assumed to be correctly specified.

4.3.2. Heteroscedasticity

One of the assumptions for the OLS estimator to be BLUE (best linear unbiased estimator) is the presence of homoscedasticity. The homoscedasticity assumption states that the variance of the error term, μ, is constant for all the values of the explanatory variables and across different segments of the population. If this assumption is violated, heteroscedasticity is present. The presence of heteroscedasticity does not cause bias or inconsistency in the OLS estimators; however, the normal standard errors become biased. As a result, the confidence intervals, t-statistics and F-tests are no longer valid (Wooldridge 2009, 264-265).

To check for heteroscedasticity in our regressions, we have applied several tests, including the White test (automatic "imtest"), Breusch-Pagan/Cook-Weisberg (automatic "hettest"), and Breusch-Pagan test (manual)[11]. In all three, we test the null hypothesis that the variance of the residuals is homogenous against the alternative hypothesis of heteroscedasticity. White's test gives us a p-value of 0.26, thus we cannot reject the null hypothesis of homoscedasticity. The same is true for the manual Breusch-Pagan test (p-value 0.46). However, the Breusch-Pagan/Cook-Weisberg test returns a very low p-value (0.0021), leading us to reject the null hypothesis of homoscedasticity. It is worth mentioning that these tests are very sensitive to model assumptions, and due to the conflicting test results, perhaps a better approach to detect heteroscedasticity is to study a scatterplot of the residuals[12]. We observe that the pattern of the data points creates a cone-like shape, indicating that the variability of the dependent variable widens as the value of the explanatory variables increases. This is an indication of heteroscedasticity.

[11] Test output can be found in appendix 4.2.
[12] Scatterplot also found in appendix 4.2.

To deal with the possible existence of heteroscedasticity, we report heteroscedasticity-robust standard errors (White) in table 9. The robust standard errors do not cause any of our variables to lose significance; on the contrary, revision of offer price becomes more significant (from 10 percent to 5 percent in all three regressions).

4.3.3. Multicollinearity

Multicollinearity is present if we have high (but not perfect) correlation between two or more independent variables in our regression. As long as we do not have perfect collinearity (i.e. an exact linear relationship between independent variables), the presence of it does not violate any of the OLS assumptions and the OLS estimators will still be BLUE. However, the issue with multicollinearity is that a high degree of correlation between independent variables may lead to large variance in the OLS slope parameters, which could result in rejection of a significant variable. Dealing with multicollinearity is not simple, and the only way to solve the issue is to either drop one or more variables (which may lead to omitted variable bias), or to collect more data in order to increase the sample size (Wooldridge 2009, 98).

Multicollinearity can be identified by observing a high R-squared and very few significant t-values, high pairwise correlation among explanatory variables, and high VIF values. Hence, to check for multicollinearity in our sample, we started by looking at our R-squared and t-values. Our largest R-squared is about 0.31 which is relatively low (the regression variables only explains about 31 percent of observed underpricing), and does not suggest that we have multicollinearity. We continued by constructing a correlation matrix for all independent variables[13]. The highest correlation coefficient is 0.72 (LN(GP) and LN(MCAP)), followed by 0.55 (LN(GP) and BB)), while the rest of the pairwise correlations are considered small (below 0.35). The high correlation between gross proceeds and market capitalization is not surprising as firm size and issue size are naturally closely related. However, the possible collinear relationship is not an issue as both LN(GP) and LN(MCAP) are used as control variables and do not affect the inference of our research variables.

Further, even though most of the pairwise correlations are small, a strong linear relationship may exist among three or more variables. Therefore, we continue the investigation by computing the VIFs (variance inflation factors) for all explanatory variables[14]. The rule of thumb for VIFs is that a value above 10 merits further investigation as it is an indication of multicollinearity. The highest VIF value is 3.79, observed for LN(GP), which suggests that multicollinearity is not an issue in our sample (UCLA Statistical Consulting Group 2016).

[13] Correlation matrix can be found in appendix 4.3.
[14] VIF values can be found in appendix 4.3.

4.3.4. Endogeneity

An endogenous explanatory variable refers to a variable that is correlated with the error term. This could be due to an omitted variable, measurement error, or simultaneity (Wooldridge 2009, 838). We assume that all of our independent variables are exogenous, but several of them could in fact be endogenous.

First, underwriter reputation is assumed exogenous in our regression, but is possibly endogenous. Habib and Ljungqvist (2001) find that the issuer's choice of underwriter is related to firm- and offering characteristics. According to their model, issuers that are assumed to gain more from low underpricing choose the most reputable underwriters. They argue that controlling for endogeneity may help reverse the positive relation between underwriter reputation and underpricing after the 1980s documented by Betty and Welch (1996) and others. However, Loughran and Ritter (2004) find that the positive relationship during the 1990s holds when controlling for the endogenous choice of lead underwriter. Thus, their results are consistent with the issuer's choosing underwriters based on non-price dimensions like analyst coverage and influence in investment community. Consequently, we assume that the positive relationship we found between initial return and underwriter reputation is reasonable.

Liu and Ritter (2011) argue that including a price revision variable can cause endogeneity. In late 1990s and 2000 in the U.S., underwriters set the file price low intentionally to later revise the price up and create the impression of a "hot issue" (referred to as a "walkup strategy"). Not all issuers agree to the walkup strategy as it involves risk for the issuer in case the underwriters set the offer price too low. Liu and Ritter (2011) further explain that issuers that care more about non-price dimensions of underwriting are more likely to agree to this strategy, thus creating a positive relationship between the usage of a walkup strategy and non-price dimensions. The price revision variable captures parts of the non-price dimension effect, and including it in the regression could cause a problem for estimating the effect of the non-price dimension on underpricing. We cannot be sure if this also applies to the Norwegian market; however, we assume that this can explain the positive coefficient of our REV variable.

Recall that Benveniste and Busaba (1997) argue that the optimal pricing mechanism depends on the characteristics of the firm. Book-building may be preferred by firms with greater capital needs, while fixed-price may be optimal for more risk-averse firms that want guaranteed proceeds. Consequently, choice of pricing mechanism is likely endogenous. However, Derrien and Womack (2003) control for endogeneity and find that their main results hold; hence, we assume that the negative relationship identified in our regression holds as well.

Previous studies have found indications of endogeneity in almost all of our explanatory variables (which are assumed exogenous). Without going into 2SLS and using instrumental variables, we

cannot be certain if our results hold. Nevertheless, based on what earlier researchers have found, we assume that our results hold when controlling for endogeneity.

4.3.5. Unusual and influential observations

Due to our small sample size, we want to check if we have any unusual observations that strongly influence our regression results. Will the coefficients change and will the statistical significance of our variables change if we eliminate the most influential observations?

To identify influential observations, we start by looking at a scatterplot of the leverage and residuals of our observations. High leverage indicates that the observation has an extreme predictor value that deviates greatly from the mean, while observations with large residuals have unusual dependent-variable values given their predictor variables. An observation with both high leverage and large residuals is considered influential, and removing it would most likely change the regression results (UCLA Statistical Consulting Group 2016). The scatterplot is illustrated below.

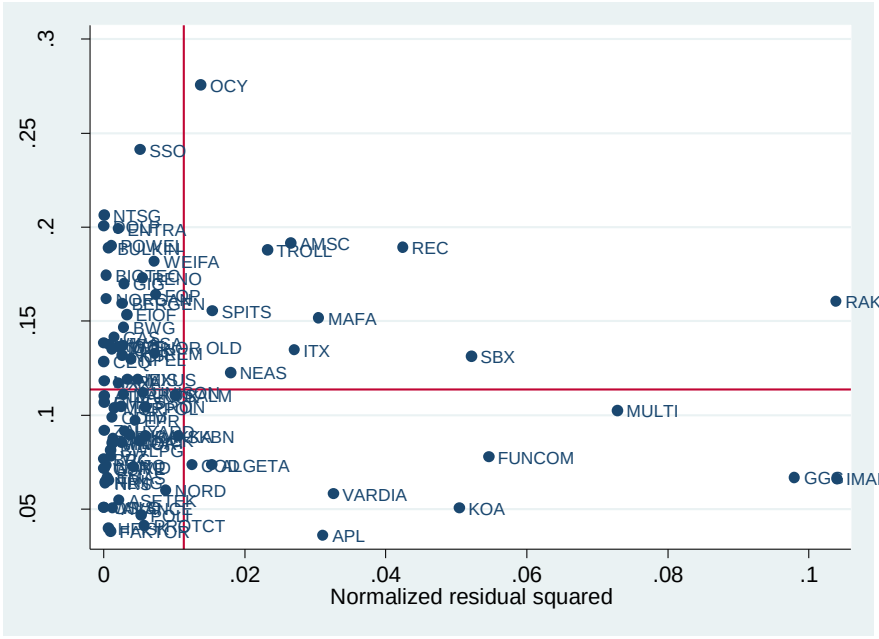

Figure 10: Scatterplot of all IPOs (TICKER) based on leverage and residuals.

We observe that the observation with the most leverage is OCY, followed by SSO. The observations with the largest residuals are RAKP, IMAREX and GGG, followed by MULTI. Some observations have both high leverage and large residuals, namely REC, AMSC, TROLL, and SBX. Thus, we start by excluding the five most unusual observations based on both leverage and residuals; OCY, SSO, RAKP, IMAREX and GGG. The IPOs that were excluded have initial returns of -1.89, 0.34, 28.63, 27.22, and 25.57 percent, respectively. The reduced sample of 83 IPOs has an average underpricing of 2.08 percent, which is lower than the average underpricing of our original sample. In addition, the positive skewness has been reduced since we drop the observations with the

highest initial returns. We rerun our regressions to check if anything changes, and the output can be found in appendix 4.4.

The coefficients on BB and LN(REP) are much smaller than in the original regression. However, they maintain their expected signs. The coefficient of REV is slightly larger, while VOL, MRET and HOT are almost identical to the original regression. None of the previously insignificant variables become significant. However, the already significant variables become more significant, both MRET and REV are now significant at the 1 percent level. Moreover, the variables are now jointly significant at the 1 percent level, and the R-squared has increased by almost 10 percent (to 26 percent). However, all the original coefficients are included in the 95 percent confidence intervals, and we cannot conclude with the reduced-sample model being significantly different from or better suited than the original regression model.

We continue by excluding the second-most unusual observations we identified from the scatterplot: MULTI, REC, AMSC, TROLL, SBX. These IPOs have initial returns of 18.88, 23.71, -3.96, 12.37, and 27.75 percent, respectively. The reduced sample size of 78 firms shows an average underpricing of 1.20 percent, which is substantially lower than identified in the original sample. The exclusion of these observations has a huge impact on the coefficient of VOL, which is now four times as large as in the original regression (-2.23). Thus, a 1 percent increase in volatility prior to an IPO is associated with 2.23 percent less underpricing. Moreover, the variable is now significant at the 10 percent level, using heteroscedasticity-robust standard errors. This finding contradicts previous studies using volatility as a proxy for ex-ante uncertainty (Derrien and Womack 2003; Lowry, Officer and Schwert 2010; Schill 2004), that find either a positive sign of VOL or no significant relationship between volatility and undepricing. Another interesting variable is LN(REP), which now has a negative sign. This indicates a negative relationship between prestigious underwriter and underpricing, which is in line with studies of IPOs in the US before the 1990s. However, the coefficient is not statistically significant.

Lastly, the variables are jointly significant at the 5 percent level, and the R-squared is still relatively large compared to the original regression (24 percent). In conclusion, the exclusion of influential variables shows how sensitive our regression model is to small changes in the sample. Due to our small sample, excluding outliers changes the size of the coefficients as well as the statistical significance of the variables. For instance, by eliminating five observations, the model explains about 10 percent more of the expected underpricing. However, the variables that we found to be significant in the original regression do not change much, and we confirm that these are relatively robust to the effect of outliers.

4.3.6. Normality of residuals

Normality of residuals is not required for OLS to yield unbiased estimates. However, normally distributed errors are required for valid hypothesis testing. Without normality of residuals, the standard errors could be biased, i.e. confidence intervals and significance tests may lead to wrong conclusions. Moreover, the OLS standard errors are no longer the smallest, meaning that OLS is no longer BLUE (WLS is more efficient).

To control for normality of residuals, we started by looking at the Kernel density function, the Q-Q plot, and the P-P plot of our residuals[15]. The kernel density estimate indicates that we have positive skewness and a higher kurtosis than the normal distribution. Moreover, the P-P plot, which is sensitive to non-normality in the middle range of data, shows signs of non-normality in the upper middle range. Finally, the Q-Q plot, which is sensitive to non-normality in the tails, clearly reveals some non-normality (especially in the upper tail). All the plots show signs of non-normality, and we apply the IQR test (inter-quartile range) to test for symmetry of the residual distribution. The presence of any severe outliers indicates that we can reject the normality assumption at the 5 percent level. The IQR test (found in appendix 4.5.) shows that we have several mild outliers, but no severe outliers. Having some mild outliers is common and should not concern us. As a result, we cannot reject the null hypothesis of a symmetric distribution.

We further apply the Jarque-Bera test for skewness and kurtosis and the Shapiro-Wilk W test for normality. Both tests return p-values close to zero, indicating that we can reject the null hypothesis of normal distribution. Hence, based on the tests and the scatterplots, we confirm that our residuals are most likely not normally distributed. Looking at the plots of the sub-sample of 78 IPOs (excluding the most influential observations), we observe that the residuals are closer to being normally distributed; however, some non-normality still appears to be present[16]. We do not attempt to fix this, but we are aware of the possibility of bias in our standard errors. Thus, we emphasize the use of robust standard errors when interpreting the regression results (UCLA Statistical Consulting Group 2016).

4.4. Interpreting results

We find that Norwegian IPOs are subject to an average market adjusted underpricing of 2.87 percent. Our objective is to determine whether the observed underpricing in Norwegian IPOs from 2005 to 2015 can be explained by a selected number of theories from the IPO underpricing literature.

[15] Kernel density estimate, P-P plot and Q-Q plot for the original sample can be found in appendix 4.5.
[16] Kernel density estimate, P-P plot and Q-Q plot for the reduced sample can be found in appendix 4.6.

The hypotheses are being statistically and economically confirmed if the coefficient of the corresponding proxy is of notable size and statistically significant at the 10 percent level. As mentioned before, we use robust standard errors to assess whether a variable is significant, as we need to correct for heteroscedasticity and non-normality of residuals.

The majority of our variables reveals the hypothesized coefficient signs and is supporting the economic interpretation. However, many of the variables are insignificant and of little size throughout all of our regressions, indicating a relatively low statistical explanatory power on the underpricing of Norwegian IPOs. Consequently, our empirical results do not support all of the selected underpricing theories. We will now provide a detailed conclusion of our hypotheses based on the empirical findings above.

Book-building

A dummy variable is included to assess the relationship between choice of pricing mechanism and underpricing in hypothesis 1. The dummy equals 1 if the firm used book-building to price the offer shares and 0 if it used fixed-price. According to our hypothesis, we expect book-building to be negatively related to the average underpricing.

The book-building dummy reveals a negative sign in the first regression, which is in line with our expectations. The coefficient of -3.01 indicates that when the IPO shares are priced using book-building, the average underpricing is expected to be 3 percent lower than if the shares were priced using the fixed-price method. Considering that our sample has an average underpricing of 2.87 percent, the economic significance of book-building is very large. Moreover, the coefficient remains negative and only experiences a slight decrease in size when control- and dummy variables are included in regression (2) and (3). Consequently, we economically support the negative relationship between book-building and underpricing found in Benveniste and Spindt (1989), Benveniste and Wilhelm (1990), and Spatt and Srivastava (1991), and the theoretical model by Benveniste and Busaba (1997). As argued in the model by Benveniste and Busaba (1997), the cost of acquiring private information from investors during book-building is lower than the cost of creating a positive cascade in a fixed-price offering, and thus the expected proceeds from a book-building IPO are higher.

However, the book-building variable has a robust t-value of –1.03 in the first regression, which means that it is statistically insignificant. The t-value does not increase when we add control- and dummy variables, and remains insignificant through all three regressions. Consequently, we cannot statistically confirm our hypothesis (1) of book-building being a more efficient pricing mechanism than fixed-price.

Market uncertainty

In order to test hypothesis 2, the market volatility in the month leading up to each IPO is included as a proxy for ex-ante uncertainty. Derrien and Womack (2003) claim that higher market volatility implies a more uncertain environment to go public, and that these periods are subject to higher underpricing. Hence, we expect the coefficient of market volatility to reveal a positive sign.

Regression (1) and (2) return a large and negative coefficient. In (2), the obtained coefficient is –0.53, which indicates that, holding other variables constant, a 1 percent increase in market volatility in the month prior to an IPO is associated with 0.53 percent less underpricing. Compared to the low average underpricing, this variable has a large economic significance. The negative coefficient is the opposite of what we expect relative to our hypothesis and is not supported by any previous research (to our knowledge). It is also inconsistent relative to the finding in the descriptive statistics, where we identified a positive pairwise correlation between annual volatility and underpricing[17]. However, the coefficient is not statistically significant.

When we include year- and industry dummies in regression (3), the sign reverses and the coefficient of VOL becomes 0.21. Holding other variables constant, this implies that a 1 percent increase in market volatility results in 0.21 percent higher underpricing. The reversal of the sign could imply that volatility is correlated with year- or industry effects, which caused the (downward) bias in the first regressions. However, when we exclude the most influential variables, the sign of VOL also becomes positive in regression (2), and the coefficient becomes statistically significant. Thus, VOL seems to be very sensitive to changes in the model, and we should be cautions when interpreting the relationship between this variable and underpricing.

Several researchers like Derrien and Womack (2003), Loughran and Ritter (2002), and Lowry and Schwert (2002) have confirmed higher underpricing among IPOs that are conducted following periods of great uncertainty. Regression (3) enables us to economically, but not statistically, confirm hypothesis (2) as the coefficient is highly insignificant, both with and without robust standard errors. Hence, we find evidence consistent with Schill (2004), that volatility has no significant impact on the level of initial returns.

Performance in the overall stock market

To test hypothesis (3), we construct a weighted market return variable to investigate how pre-IPO stock market performance (public signals) affects the level of underpricing. Researchers suggest that market movements prior to an IPO are only partially incorporated into the share price, thus we hypothesize to find a positive relationship between MRET and underpricing.

[17] Correlation matrix in appendix 3.2.

All three regressions reveal a large and positive coefficient. The size of the coefficient decreases when controlling for age, firm size and issue size, indicating that the weighted market return variable might have captured some of the effects from one or more of the control variables when these were not present in the model. The size of the variable is almost constant at a level of 0.65 in regression (2) and (3), suggesting that the economic significance of the variable remains very large, even when controlling for industry- and year dummies. The coefficient of MRET implies that a 1 percent increase in OSEAX is associated with 0.65 percent higher underpricing of Norwegian IPOs, holding other variables constant.

Further, the variable is statistically significant at the 1 percent and 5 percent level in regression (1) and (2), respectively. However, MRET becomes insignificant when controlling for year- and industry dummies. Still, a p-value of 0.117 indicates that it is close to significant at the 10 percent level, and the result does not seem to be driven by random sampling errors. Consequently, we can (to some extent) confirm the market hypothesis and the findings of Loughran and Ritter (2002) and Derrien and Womack (2003). Our results suggest that an increase in the performance of the OSEAX is associated with higher underpricing on average, which further indicates that the offer price in Norwegian offerings is not fully adjusted to market movements prior to the IPO.

Underwriter reputation

In order to test hypothesis 4, we include a variable for underwriter reputation, measured by each underwriter's average market share of total gross proceeds raised in the Norwegian market over the sample period. The most prominent theory of underwriter reputation states that issuing firms can hire prestigious underwriters to signal their low risk to the market, which reduces the need for underpricing. As previously mentioned, the empirical studies of underwriter reputation discover a negative relationship with underpricing prior to the 1990s, and a positive link in the 1990s and the first part of the 2000s[18]. We base our hypothesis on the main theory of prestigious underwriters being used as a certification of firm quality, and consequently we expect a negative relationship between LN(REP) and underpricing.

The first regression reveals a positive coefficient of 0.14, and the variable remains positive through regression (2) and (3). The variable increases in size and becomes slightly more significant when we include the control variables. Regression (2) shows that a 10 percent increase in underwriter reputation (market share) entails a 1.6 percent higher initial return, holding other variables constant. However, when controlling for industry- and year dummies, the coefficient decreases and becomes less significant.

[18] To our knowledge, no research paper includes IPOs after 2008, which is the last year in the sample used by Liu and Ritter (2011).

The regression results enable us to economically reject our hypothesis of a negative relationship between underwriter reputation and first-day returns of Norwegian IPOs. Contrarily, we can economically confirm the positive relationship observed after the 1980s, which is supported by Beatty and Welch (1996), Cooney et al. (2001), and Loughran and Ritter (2004). Beatty and Welch (1996) state that the reversed sign can be explained by changes in the economic environment, while Cooney et al. (2001) argue that it is due to the changed behavior of either the issuer or the underwriter. Liu and Ritter (2011) extend the theory of changing issuer behavior and claim that the positive sign is explained by the fact that issuers care more about non-price dimensions of underwriting than they originally did. However, the positive relationship cannot be statistically confirmed.

Revision of offer price

The REV variable is included in the regression to investigate hypothesis 5. The research variable captures the percentage change in price between the midpoint of the indicative price range and the final offer price. Hanley's (1993) partial adjustment theory claims that when issuers are faced with unexpectedly high demand during the book-building process, the price is not fully adjusted to reflect the true value of the shares. As a consequence, high initial returns are expected when the offer price has been revised up and we expect to find a positive relationship between REV and UP.

The price revision variable is positive and significant, as hypothesized. Regression (1) reveals a coefficient of 0.13, which increases to 0.18 and becomes more significant when control variables and year- and industry dummies are added. Holding other variables constant, the coefficient of REV suggest that if the offer price has been revised up by 10 percent in the book-building period, the initial return of the IPO is expected to be 1.8 percent higher. The variable appears to be robust, as it remains significant at the 5 percent level through all regressions.

Based on our positive and significant coefficient, we conclude that offerings where the price has been revised up are in fact associated with higher underpricing, on average. Hence, our finding supports Hanley (1993) and Edelen and Kadlec (2005). It appears that Norwegian underwriters do not fully adjust the offer price to reflect information revealed during the book-building process. This could be explained by the model of Benveniste and Busaba (1997), where it is observed that investors require some underpricing as compensation for truthfully revealing their interest during the book-building process. Alternatively, as explained by Edelen and Kadlec (2005), the issuers may adjust their expectations of IPO share value relative to the valuation of comparable companies instead of revealed demand. If so, an increase in market valuation of similar firms will lead to a partial upwards revision of the offer price, and subsequently higher initial returns of the IPO. Lastly, the finding is in line with the behavioral bias of issuers explained by Loughran and Ritter (2002). They argue that issuers do not care about underpricing and reduced gross proceeds as long as their personal wealth increases.

IPO activity

In order to test hypothesis 6, a HOT dummy variable is constructed. The dummy variable takes the value 1 if the IPO occurred in a "hot" period and 0 otherwise. The level of IPO activity has traditionally been identified by either a volume measure; such as number of new issues (Ritter 1984) or issue size in dollars (Ritter and Welch 2002), or a pricing measure; such as the level of underpricing (Ibbotson and Jaffe 1975; Ritter 1984). In the descriptive statistics, we investigated the relationship between number of IPOs, market condition and underpricing, and found no indications of a relationship between underpricing and the measure of "hot" periods. This could be due to the low number of firms going public each year in our sample (and the large effect one IPO can have on this measure). Therefore, we used another volume measure; equity issued on OB, to define the "hot issue" markets used to construct the dummy variable. Hypothesis 6 is motivated by the conventional wisdom in the previous IPO literature; that "hot issue" periods should be associated with higher initial returns. Hence, we expect to find a positive sign of the HOT dummy.

All three regressions reveal a positive sign that ranges between 1.13 and 2.21. In regression (2), the coefficient of 2.21 indicates that the average underpricing in "hot issue" markets is expected to be 2.21 percent higher than the underpricing in "cold" or "neutral" markets. Thus, we can confirm that the period in which the firms go public has economic significance on the average underpricing of Norwegian IPOs, which is in line with the findings of e.g. Ritter (1984) and Ibbotson, Sindelar and Ritter (1988). However, with t-values below 1.17, the coefficient remains insignificant through all regressions.

Lastly, the R-squared remains relatively low throughout our regressions. However, this is not unusual when conducting a cross-sectional analysis and it does not necessarily mean that the relationship between our selected variables is weak (Wooldridge 2009, 41). Moreover, the quality of the regression results does not directly rely on the level of R-squared. A low R-squared is in line with other empirical studies (e.g. Beatty and Welch 1996), and may be explained by the fact that underpricing is hard to predict (Wooldridge 2009, 83). As we have seen, none of the numerous theories of underpricing that has been developed to try and explain the underpricing phenomenon has been able to fully explain the high initial returns.

In conclusion, we find that only two of the selected underpricing theories are useful in explaining the observed underpricing among Norwegian IPOs, which implies that further research needs to be done.

5. Conclusion

The underpricing phenomenon has been extensively researched in larger economies, especially in the U.S. However, only a small number of studies have been conducted in smaller economies like Norway. As a result, the purpose of this thesis has been to investigate if some of the most supported underpricing theories from the IPO literature are useful in explaining the observed underpricing of Norwegian IPOs. A sample of 88 firms going public on the Oslo Stock Exchange in the period from January 1, 2005 to December 31, 2015 has been used to assess this relationship.

We find an average market-adjusted underpricing of 2.87 percent for the IPOs in our sample, which is slightly lower than the initial return documented in previous studies of Norwegian IPOs. However, it appears that the level of underpricing in Norway has been decreasing from 1984 to 2013, and the low initial return we observe indicates a continuance of this trend.

In order to answer our problem statement, six research hypotheses motivated by the conventional IPO literature have been developed. Further, we have constructed proxy variables that enable us to empirically test the hypotheses. After running three regressions, we find evidence in support of Hanley's (1993) partial adjustment theory. That is, it appears that Norwegian underwriters do not fully adjust the offer price to reflect information obtained in the period prior to the IPO. This can be explained by the fact that informed investors require compensation for truthfully revealing their private information in the book-building process, as observed in the model by Benveniste and Busaba (1997). Alternatively, the significance of price revision in explaining underpricing can be due to behavioral biases among Norwegian issuers. As explained by Loughran and Ritter (2002), it could be that the issuers sum the gain from increased proceeds with the loss from the higher underpricing, and do not care about leaving more money on the table as long as their net wealth increases. Lastly, Edelen and Kadlec (2005) argue that issuers consider the market valuation of comparable companies when adjusting the offer price. Thus, if the valuation of similar firms in Norway is high, the issuer that is in the process of going public may become risk-averse and choose to underprice the shares to avoid IPO failure.

Moreover, we find that the market return of the OSEAX prior to an IPO is useful in predicting the average initial return, which also can be explained by the partial adjustment theory. It appears that Norwegian underwriters fail to incorporate favorable market conditions into the final offer price, resulting in high first-day returns. Thus, we are able to confirm the findings of Loughran and Ritter (2002) and Derrien and Womack (2003), and conclude that their observations in the U.S. and French market also apply to the Norwegian IPO market.

Our results contribute to the IPO literature by having two main implications for potential investors. First, if the return of the OSEAX is increasing in the months prior to an IPO, the investors can expect to realize a higher initial return, on average. Secondly, if the share price is revised upwards relative to the midpoint of the indicative price range, the investors can assume that the IPOs will be subject to higher underpricing.

Finally, it appears that our research variables are jointly significant in explaining the underpricing of Norwegian IPOs. However, the majority of our variables remain individually insignificant throughout the analysis. Hence, we cannot confirm that going public in a "hot issue" market entails higher initial returns than going public in a "cold" or "neutral" market. Moreover, we cannot confirm that volatility prior to an IPO, the reputation of the lead underwriter, or the mechanism used to price the offer shares are factors that have any significant impact on the level of underpricing in Norwegian IPOs. Altogether, our variables are only able to explain about 30 percent of the observed underpricing, which indicates that initial returns are hard to predict in general. This is in line with the findings of previous researchers, and suggests that investors cannot easily select the IPOs that are associated with abnormal returns.

As a result, further research is necessary in order to fully explain the underpricing in the Norwegian IPO market. This may include developing new theories of underpricing, or testing other existing aspects of high initial return that have not been tested in our thesis, but have received empirical support in the U.S., such as principal-agent theory, signaling theory, investor sentiment or control theories. However, in order to test some of the existing theories, new variables may need to be constructed for the Norwegian stock market. For instance, the investor sentiment theory could be tested if an investment sentiment index is created for the Norwegian market, and in order to test the signaling theory, one could use a ranking system for Norwegian stocks. Alternatively, one could test our hypotheses with a larger sample, or by instrumental variable regression in order to control for endogeneity. As the majority of our research variables reveal the expected coefficient, re-doing the analysis with a larger sample may make the coefficients statistically significant. Moreover, it may be easier to obtain a larger sample of Norwegian IPOs going forward because more information is publicly available. For instance, all listing prospectuses are now published on NewsWeb, thus fewer IPOs need to be excluded due to missing data. However, the number of firms going public at the Oslo Stock Exchange may be affected by the "oil crisis" that recently struck Norway, and we may see fewer firms going public, especially within the energy sector, over the next years.

6. Bibliography

Abrahamson, Mark, Tim Jenkinson and Howard Jones. 2011. Why Don't U.S. Issuers Demand European Fees for IPOs? *The Journal of Finance, 66(6),* 2055-2082.

Aggarwal, Reena and Pat Conroy. 2000. Price Discovery in Initial Public Offerings and the Role of the Lead Underwriter. *The Journal of Finance, 55(6),* 2903-2922.

Allen, Franklin and Gerald R. Faulhaber. 1989. Signaling by Underpricing in the IPO Market. *Journal of Financial Economics, 23(2),* 303-323.

Amihud, Yakov, Shmuel Hauser and Amir Kirsh. 2003. Allocations, Adverse Selection, and Cascades in IPOs: Evidence from the Tel Aviv Stock Exchange. *Journal of Financial Economics, 68(1),* 137-158.

Banerjee, Suman and Keshab Shrestha. 2011. Cross-country IPOs: What Explains Differences in Underpricing? *Journal of Corporate Finance, 17(5),* 1289-1305.

Bansal, Rohit and Ashu Khanna. 2012. Determinants of IPOs Initial Return: Extreme Analysis of Indian Market. *Journal of Financial Risk Management, 1(4),* 68-74.

Baron, David. 1982. A Model of the Demand of Investment Banking Advising and Distribution Services for New Issues.*The Journal of Finance, 37(4),* 955-976.

Beatty, Randolph P. and Ivo Welch. 1996. Issuer Expenses and Legal Liability in Initial Public Offerings. *Journal of Law & Economics, 39(2),* 545-602.

Beatty, Randolph P. and Jay R. Ritter. 1986. Investment Banking, Reputation, and the Underpricing of Initial Public Offerings. *Journal of Financial Economics, 15(1-2),* 213-232.

Benveniste, Lawrence M. and Walid Y. Busaba. 1997. Bookbuilding vs. Fixed Price: An Analysis of Competing Strategies for Marketing IPOs. *Journal of Financial and Quantitative Analysis, 32(4),* 383-403.

Benveniste, Lawrence M. and William J. Wilhelm. 1990. A Comparative Analysis of IPO Proceeds under Alternative Regulatory Environments. *Journal of Financial Economics, 28(1-2),* 173-207.

Benveniste, Lawrence M. and Paul A. Spindt. 1989. How Investment Bankers Determine the Offer Price and Allocation of New Issues. *Journal of Financial Economics, 24(2),* 343–361.

Biais, Bruno and Anne Marie Faugeron-Crouzet. 2002. IPO Auctions: English, Dutch,… French, and Internet. *Journal of Financial Intermediation, 11(1),* 9-36.

Booth, James R. and Richard L. Smith. 1986. Capital Raising, Underwriting and the Certification Hypothesis. *Journal of Financial Economics, 15(1),* 261–281.

Brennan, Michael J., and Julian Franks. 1997. Underpricing, Ownership and Control in Initial Public Offerings of Equity Securities in the UK. *Journal of Financial Economics, 45(3),* 391-413.

Busaba, Walid Y. and Chun Chang. 2010. Bookbuilding vs. Fixed Price Revisited: The Effect of Aftermarket Trading. *Journal of Corporate Finance, 16(3),* 370-381.

Bustamante, Maria C. 2012. The Dynamics of Going Public. *Review of Finance, 16(2),* 577-618.

Carter, Richard B., Frederick H. Dark and Ajai K. Singh. 1998. Underwriter Reputation, Initial Returns, and the Long-Run Performance og IPO Stocks. Journal of Finance, *53(1),* 285-311.

Carter, Richard B. and Steven Manaster. 1990. Initial Public Offerings and Underwriter Reputation. *Journal of Finance, 45(4),* 1045-1067.

Chahine, Salim. 2008. Underpricing Versus Gross Spread: New Evidence on the Effect of Sold Shares at the Time of IPOs. *Journal of Multinational Financial Management, 18(2),* 180-196.

Chambers, David and Elroy Dimson. 2009. IPO Underpricing over the Very Long Run. *The Journal of Finance, 64(3),* 1407-1443.

Chen, Zhaohiu and William J. Wilhelm. 2008. A Theory of the Transition to Secondary Market Trading of IPOs. *Journal of Financial Economics, 90(3),* 219-236.

Cooney, John W., Ajai K. Singh, Richard B. Carter and Frederick H. Dark. 2001. IPO Initial Returns and Underwriter Reputation: Has the Inverse Relationship Flipped in the 1900s? *Unpublished University of Kentucky, Case Western Reserve, and Iowa State working paper*.

Cornelli, Francesca, David Goldreich and Alexander P. Ljungqvist. 2006. Investor Sentiment and Pre-IPO Markets. *The Journal of Finance, 61(3),* 1187-1216.

Derrien, Francis and Kent L. Womack. 2003. Auctions vs. Bookbuilding and the Control of Underpricing in Hot IPO Markets. *Review of Financial Studies, 16(1),* 31-61.

Drake, Philip D and Michael R. Vetsuypens. 1993. IPO Underpricing and Insurance Against Legal Liability. *Financial Management, 22(1),* 64-73.

Dunbar, Craig G. 2000. Factors Affecting Investment Bank Initial Public Offering Market Share. *Journal of Financial Economics, 55(1),* 3-41.

Edelen, Roger M. and Gregory B. Kadlec. 2005. Issuer Surplus and the Partial Adjustment of IPO Prices to Public Information. *Journal of Financial Economics, 77(2),* 347-373.

Emilsen, Nina H., Kathrine Pedersen and Frode Sættem. 1997. Børsintroduksjoner. *BETA Tidsskrift for Bedriftsøkonomi*, 11(1), 1-13.

Engelen, Peter-Jan and Marc Van Essen. 2010. Underpricing of IPOs: Firm-, Issue- and Country-specific Characteristics. *Journal of Banking and Finance, 34(8),* 1958-1969.

Eraydin, Kivilcim. 2008. *The Underpricing and Long Run Performance of Initial Public Offerings – Evidence from Turkey.* Sweden: Department of Economics.

Field, Laura C., and Jonathan M. Karpoff. 2002. Takeover Defenses at IPO Firms. *The Journal of Finance, 57(5),* 1857-1889.

Fjesme, Sturla Lyngnes. 2015. Initial Public Offering Allocations, Price Support, and Secondary Investors. *Forthcoming, Journal of Financial and Quantitative Analysis.*

Grinblatt , Mark and Chuan Y. Hwang. 1989. Signaling and the Pricing of New Issues. *The Journal of Finance, 44(2),* 393-420.

Güçbilmez, Ufuk. 2015. IPO Waves in China and Hong Kong. *International Review of Financial Analysis, 40(1),* 14-26.

Guo, Re-Jin, Baruch Lev and Charles Shi. 2006. Explaining the Short- and Long-Term IPO Anomalies in the US by R&D. *Journal of Business Finance & Accounting, 33(3-4),* 550-579.

Habib, Michel A. and Alexander P. Ljungqvist. 2001. Underpricing and Entrepreneurial Wealth Losses in IPOs: Theory and Evidence. *Review of Financial Studies, 14(2),* 433-458.

Hanley, Kathleen W. 1993. The Underpricing of Initial Public Offerings and the Partial Adjustment Phenomenon. *Journal of Financial Economics, 34(2),* 231-250.

Hanley, Kathleen W. and William J. Wilhelm. 1995. Evidence on the Strategic Allocation of Initial Public Offerings.*Journal of Financial Economics, 37(2),* 239-257.

Hanley, Kathleen W., Arun A. Kumar and Paul J. Seguin. 1993. Price Stabilization in the Market for New Issues. *Journal of Financial Economics, 34(2),* 177-197.

Henrick, Bryan. 2012. *The Role of Industry Affiliation in the Underpricing of U.S. IPOs.* Lancaster.

Hensler, Douglas A. 1995. Litigation Costs and the Underpricing of Initial Public Offerings. *Managerial and Decision Economics, 16(2),* 111-128.

Hughes, Patricia J. and Anjan V. Thakor. 1992. Litigation Risk, Intermediation, and the Underpricing of Initial Public Offerings. *The Review of Financial Studies, 5(4),* 709-742.

Ibbotson, Roger G. 1975. Price Performance of Common Stock new Issues. *Journal of Financial Economics, 2(3),* 235-272.

Ibbotson, Roger G. and Jeffrey F. Jaffe. 1975. "Hot Issue" Markets. *Journal of Finance, 30(4),* 1027-1042.

Ibbotson, Roger G., Jody L. Sindelar and Jay R. Ritter. 1988. Initial Public Offerings. *Journal of Applied Corporate Finance, 1(2),* 37-45.

Ibbotson, Roger G., Jody L. Sindelar and Jay R. Ritter. 1994. The Market's Problems with the Pricing of Initial Public Offerings. *Journal of Applied Corporate Finance, 7(1),* 66-74.

Keloharju, Matti. 1993. The Winner's Curse, Legal Liability, and the Long-run Price Performance of Initial Public Offerings in Finland. *Journal of Financial Economics, 34(2),* 251-277.

Lee, Peggy M and Sunil Wahal. 2004. Grandstanding, Certification, and the Underpricing of Venture Capital Backed IPOs. *Journal of Financial Economics, 73(2),* 375-407.

Levis, Mario. 1990. The Winner's Curse Problem, Interest Costs, and the Underpricing of Initial Public Offerings. *The Economic Journal, 100(399),* 76-89.

Liu, L. Xiaoding, Ann E. Sherman and Yong Zhang. 2009. Media Coverage and IPO Underpricing. *AFA 2009 San Francisco Meetings Paper.*

Liu, L. Xiaoding and Jay R. Ritter. 2011. Local Underwriter Oligopolies and IPO Underpricing. *Journal of Financial Economics, 102(3),* 579-601.

Ljungqvist, Alexander P., Tim Jenkinson and William J. Wilhelm. 2003. Global Integration in Primary Equity Markets: The Role of U.S. Banks and U.S. Investors. *Review of Financial Studies, 16(1),* 63-99.

Ljungqvist, Alexander P and William J. Wilhelm. 2005. Does Prospect Theory Explain IPO Market Behavior? *The Journal of Finance, 60(4),* 1759-1790.

Ljungqvist, Alexander P., Rajdeep Singh and Vikram K. Nanda. 2006. Hot Markets, Investor Sentiment, and IPO Pricing. *The Journal of Business, 79(4),* 667-1702.

Logue, Dennis E. 1973. On the Pricing of Unseasoned Equity Issues: 1965-1969. *Journal of Financial and Quantitative Analysis, 8*(1), 91-103.

Loughran, Tim and Jay R. Ritter. 2002. Why Dont Issuers Get Upset About Leaving Money on the Table in IPOs? *Review of Financial Studies, 15(2),* 413-444.

Loughran, Tim and Jay R. Ritter. 2004. Why Has IPO Underpricing Changed Over Time? *Financial Management, 33(3),* 5-37.

Loughran, Tim, Jay R. Ritter and Kristian Rydqvist. Updated 2015. Initial Public Offerings: International Insights. *Published in the June 1994 Pacific-Basin Finance Journal, 2(2-3),* 165-199.

Lowry, Michelle, Micah S. Officer and G. William Schwert. 2010. The Variability of IPO Initial Returns. *The Journal of Finance, 65(2),* 425-465.

Lowry, Michelle and G. William Schwert. 2002. IPO Market Cycles: Bubbles or Sequential Learning? *Journal of Finance, 57(3),* 1171-1200.

Lowry, Michelle and Susan Shu. 2002. Litigation Risk and IPO Underpricing. *Journal of Financial Economics, 65(3*), 309-335.

McDonald, John G. and A. K. Fisher. 1972. New-Issue Stock Price Behavior. *The Journal of Finance, 27(1),* 97-102.

Megginson, William L. and Kathleen A. Weiss. 1991. Venture Capitalist Certification in Initial Public Offerings. *Journal of Finance, 46(3),* 879-903.

Muscarella, Chris J. and Michael R. Vetsuypens. 1989. A Simple Test of Baron's Model of IPO Underpricing. Journal of Financial Economics 24(1), 125–135.

Ofek, Eli and Matthew Richardson. 2003. DotCom Mania: The Rise and Fall of Internet Stock Prices. *The Journal of Finance, 58(3),* 1113-1137.

Purnanandam, Amiyatosh K and Bhaskaran Swaminathan. 2004. Are IPOs Really Underpriced? *The Review of Financial Studies, 17(3),* 811-848.

Reilly, Frank K. and Kenneth Hatfield. 1969. Investor Experience with New Stock Issues. *Financial Analysts Journal, 25(5),* 73-80.

Ritter, Jay R. 1984. The "Hot Issue" Market of 1980. *The Journal of Business, 57(2),* 215-240.

Ritter, Jay R. 1991. The Long-Run Performance of Initial Public Offerings. *Journal of Finance, 46(1),* 3-27.

Ritter, Jay R. and Ivo Welch. 2002. A Review Of IPO Activity, Pricing, And Allocations. *Journal of Finance, 57(4),* 1795-1828.

Rock, Kevin. 1986. Why New Issues are Underpriced. *Journal of Financial Economics, 15(1),* 187-212.

Ruud, Judith S. 1993. Underwriter Price Support and the IPO Underpricing Puzzle. *Journal of Financial Economics, 34(2),* 135-151.

Schill, Michael J. 2004. Sailing in Rough Water: Market Volatility and Corporate Finance. *Journal of Corporate Finance, 10(5),* 659-681.

Schultz, Paul H. and Mir A. Zaman. 1994. After-market Support and Underpricing of Initial Public Offerings. *Journal of Financial Economics, 35(2),* 199-219.

Spatt, Chester and Sanjay Srivastava.1991. Preplay Communication, Participation Restrictions, and Efficiency in Initial Public Offerings. *Review of Financial Studies, 4(4),* 709-726.

Stoll, Hans R. and Anthony J. Curley. 1970. Small Business and the New Issues Market for Equities. *The Journal of Financial and Quantitative Analysis, 5(3),* 309-322.

Stoughton, Neal M. and Josef Zechner. 1998. IPO Mechanisms, Monitoring and Ownership Structure. *Journal of Financial Economics, 49(1),* 45-77.

Su, Dongwei and Belton M. Fleisher. 1999. An Empirical Investigation of Underpricing in Chinese IPOs. Pacific-Basin Finance Journal, 7(2), 173– 202.

Thaler, Richard. 1980. Toward a Positive Theory of Consumer Choice. *Journal of Economic Behavior and Organization, 1(1),* 39-60.

Thaler, Richard. 1985. Mental Accounting and Consumer Choice. *Marketing Science, 4(3),* 199- 214.

Tinic, Seha. 1988. Anatomy of Initial Public Offerings of Common Stock. *Journal of Finance, 43(4),* 789-822.

Titman, Sheridan and Brett Trueman. 1986. Information Quality and the Valuation of New Issues. *Journal of Accounting and Economics, 8(2),* 159-172.

Welch, Ivo. 1992. Sequential Sales, Learning and Cascades. *Journal of Finance, 47(2),* 695–732.

Books

Berk, Jonathan and Peter DeMarzo. 2014. *Corporate Finance (3rd Edition)*. Boston: Pearson Education.

Brealey, Richard A., Stewart C. Myers and Franklin Allen. 2011. *Principles of Corporate Finance (10th Edition).* New York: McGraw-Hill Companies.

Dietrich, Justyna. 2012. *Variables Influencing the Severity of IPO Underpricing: An Empirical Analysis of the German Market*. Hamburg: Diplomica Verlag.

Espinasse, Philippe. 2011. *IPO: A Global Guide.* Hong Kong: Hong Kong University Press, HKU.

Gibbons, Jean D. 1993. *Nonparametric Statistics.* SAGE Publications.

Reiche, Oliver. 2014. *The Phenomenon of IPO Underpricing in the European and U.S. Stock Markets*. Anchor Academic Publishing.

Wooldridge, Jeffrey M. 2009. *Introductory Econometrics: A Modern Approach (4th Edition).* Mason, OH ; South Western Cengage Learning.

Websites

BlauStein Lawyers. 2016. *Initial Public Offerings (IPO).* Retrieved 11.05.2016, from http://blaustein.pro/solutions/initial-public-offering.html

Bloomberg. 2015. *One of the Biggest Tech IPOs of All Time Is Getting Bought by a Teen Clothing Store.* Retrieved 01.05.2016, from http://www.bloomberg.com/news/articles/2015-05-26/one-of-the-biggest-tech-ipos-of-all-time-just-got-bought-by-a-teen-clothing-store

Colgate, Adam. 2016. *Why Does a Company Decide to Go Public?* Retrieved 05.04.16, from http://www.businessdictionary.com/article/780/why-does-a-company-decide-to-go-public/

Hunger, Adrian. 2016. *IPO-underpricing.com*. Retrieved 24.05.16, from http://www.ipo-underpricing.com/UP/Underpricing/Basics/e_upbasics2analytik.html

InvestorGuide. 2016. *What is the Difference Between Retail Investors and Institutional Investors?* Retrieved 11.05.16, from http://www.investorguide.com/article/11202/what-is-the-difference-between-retail-investors-and-institutional-investors/

Masters, Terry. 2016. *Disadvantages of a Business Going Public.* Retrieved 06.04.16, from http://smallbusiness.chron.com/disadvantages-business-going-public-46387.html

PricewaterhouseCoopers. 2011. *Roadmap for an IPO; A guide to going public.* Retrieved 07.05.16, from http://www.pwc.com/us/en/deals/publications/assets/pwc-roadmap-to-an-ipo.pdf

PricewaterhouseCoopers. 2014. *A guide to going public: Executing a successful IPO in Oslo.* Retrieved 04.04.16, from https://www.pwc.no/no/publikasjoner/boers/ipo-guide-2014.pdf

Rawani, Anand. 2009. *What is book-building?* Retrieved 12.05.16, from http://articles.economictimes.indiatimes.com/2009-08-09/news/27665381_1_book-building-issue-price-floor-price

Reference for Business. 2016. *Initial Public Offerings*. Retrieved 02.02.16, from http://www.referenceforbusiness.com/small/Inc-Mail/Initial-Public-Offerings.html

Taulli, Tom. 2012. *4 Reasons Companies Go Public: It's Mostly About the Money — but not Entirely*. Retrieved 05.04.16, from http://investorplace.com/ipo-playbook/4-reasons-companies-go-public/

UCLA Statistical Consulting Group. 2016. Stata Web Books: Regression with Stata; Chapter 2 – Regression Diagnostics. Retrieved 20.05.16, from http://www.ats.ucla.edu/stat/stata/webbooks/reg/chapter2/statareg2.htm

Oslo Børs

Oslo Børs. 2013. *OBX-indeksen passerte 500 for første gang*. Retrieved 14.04.16, from http://www.oslobors.no/Oslo-Boers/Om-Oslo-Boers/Nyheter-fra-Oslo-Boers/OBX-indeksen-passerte-500-for-foerste-gang

Oslo Børs. 2014. *The Equal Treatment Rule in Securities Legislation.* Circular No. 2/2014. Oslo: Oslo Børs.

Oslo Børs. 2016a. *Listing Rules for Equities on Oslo Børs*. Retrieved 01.06.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/Regulations/The-Issuer-Rules

Oslo Børs. 2016b. *Shares, Equity Certificates and Rights to Shares.* Retrieved 04.04.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/Listing/Shares-equity-certificates-and-rights-to-shares

Oslo Børs. 2016c. *About Oslo Børs*. Retrieved 05.04.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/About-Oslo-Boers

Oslo Børs. 2016d. *Trading*. Retrieved 14.04.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/Trading

Oslo Børs. 2016e. *The Difference Between Oslo Børs and Oslo Axess*. Retrieved 14.04.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/Listing/Shares-equity-certificates-and-rights-to-shares/Oslo-Boers-and-Oslo-Axess/The-difference-between-Oslo-Boers-and-Oslo-Axess

Oslo Børs. 2016f. *Nordic ABM*. Retrieved 15.04.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/Listing/Interest-bearing-instruments/Nordic-ABM

Oslo Børs. 2016g. *Oslo Børs to Launch a New Regulated Marketplace*. Retrieved 15.04.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/About-Oslo-Boers/News-from-Oslo-Boers/Oslo-Boers-to-launch-a-new-regulated-marketplace

Oslo Børs. 2016h. *Instruments*. Retrieved 15.04.16, from http://www.oslobors.no/ob_eng/Oslo-Boers/Trading/Instruments

Articles or chapters in books

Álvarez-Otero, Susana and Víctor M. González-Méndez. 2006. *The Size Effect of Firms Going Public on the Spanish Capital Market.* Initial Public Offerings: An International Perspective, Greg N. Gregoriou, 65-79. Oxford: Butterworth-Heinemann.

Günther, Stefan and Marco Rummer. 2006. *The Hot-Issue Period in Germany: What Factors Drove IPO Underpricing?* Initial Public Offerings: An International Perspective, Greg N. Gregoriou, 215-245. Oxford: Butterworth-Heinemann.

Ljungqvist, Alexander 2007. *IPO Underpricing.* Handbook in Corporate Finance: Empirical Corporate Finance vol. 1. B. Espen Eckbo. (2007). Pages 375–422. North Holland.

Figures and tables

Figure 2: Oslo Børs. 2016i. *Share indices.* Pie created from OSE10GI-OSE55GI. Retrieved 01.06.16, from *http://www.oslobors.no/markedsaktivitet/#/list/shareindices/quotelist/intraday*

Figure 3: Oslo Børs. 2016j. *Issues Oslo Børs 1997-2016.* Excel-file. Retrieved 15.05.16 from ttp://www.oslobors.no/ob_eng/Oslo-Boers/Statistics

Figure 4: Loughran, Tim, Jay R. Ritter and Kristian Rydqvist. Updated 2015. Initial Public Offerings: International Insights. *Published in the June 1994 Pacific-Basin Finance Journal Vol. 2, pp. 165-199.*

Figure 5: Oslo Børs. 2016k. *Historical prices – linked indices.* Excel-file. Retrieved 15.05.16 from http://www.oslobors.no/ob_eng/Oslo-Boers/Products-and-services/Market-data/Equity-indices

7. Appendix

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1. The theoretical model comparing fixed-price and book-building by Benveniste and Busaba (1997)

1.1. Proof of fact 3.

Benveniste and Busaba refer to Welch's (1992) Lemma 3 and change the notation to fit their own model. The lemma derives the probability of observing h U signals in the total of H signals given that we observe i U signals in the total of m signals in another sample drawn from the same distribution. If C_h^H denotes the combination of H outcomes, h by h, the probability can be expressed as:

$$prob(h\ U\ signals\ in\ H|i\ U\ signals\ in\ m) = \frac{C_h^H x C_i^m}{C_{h+i}^{H+m}}\left(\frac{m+1}{H+m+1}\right),$$

where C_h^H is given by

$$C_h^H = \frac{H!}{h!(H-h)!}.$$

In Benveniste and Busaba's model, i=m=1. Substituting this into the expression along with the fact that the investor wants to calculate the probability of the remaining H-1 investors holding h U signals, we get

$$\pi_h' = prob(h\ Us\ in\ H-1|1;1) = \frac{C_h^{H-1} x C_1^1}{C_{h+1}^H}\left(\frac{2}{H+1}\right), h = 0, \dots, H-1.$$

We can simplify this expression using factorials,

$$\frac{\frac{H-1!}{h!((H-1)-h)!1!(1-1)!}\quad\frac{1!}{}}{\frac{H!}{h+1!(H-(h+1))!}}\left(\frac{2}{H+1}\right) = \frac{\frac{H-1!}{h!}*1}{\frac{H!}{h+1!}}\left(\frac{2}{H+1}\right)$$

$$= \frac{H-1!}{h!}\frac{h+1!}{H!}\left(\frac{2}{H+1}\right) = \frac{H-1!}{h!}\frac{h+1!}{H(H-1)!}\left(\frac{2}{H+1}\right) = \frac{1}{h!}\frac{h(h+1)!}{H}\left(\frac{2}{H+1}\right) = \boldsymbol{\frac{2(h+1)}{H(H+1)}},$$

and we end up with the expression **(2a).**

The conditional probabilities when i=0 in expression (2b) is derived in a similar way,

$$\pi_h'' = prob(h\ Us\ in\ H-1|0;1) = \frac{C_h^{H-1} x C_0^1}{C_h^H}\left(\frac{2}{H+1}\right), h = 0, \dots, H-1,$$

and this can also be simplified using factorials

$$\frac{\frac{H-1!}{h!((H-1)-h)!0!(1-0)!}}{\frac{H!}{h!(H-h)!}}\left(\frac{2}{H+1}\right)=\frac{H-1!}{h!((H-1)-h)!}\frac{h!(H-h)!}{H(H-1)!}\left(\frac{2}{H+1}\right)$$

$$=\frac{1}{(H-1-h)!}\frac{(H-h)!}{H}\left(\frac{2}{H+1}\right)$$

$$=\frac{H-h}{(H-h)!}\frac{(H-h)!}{H}\left(\frac{2}{H+1}\right)=\boldsymbol{\frac{2(H-h)}{H(H+1)}}.$$

1.2. Proof of Welch's (1992) theorem 5.

«THEOREM 5: An uninformed risk-neutral issuer optimally chooses the full- subscription price (Θ= 1/3), and all offerings succeed. Successful offerings can ex-post be either over- or underpriced. The expected IPO underpricing (initial return) is between 0% and 50%».

Welch assumes that the issuer's private valuation θ^P is zero (the shares that are not sold are worthless). He shows that an issuer is always better off choosing $P^o = \frac{1}{3}$ than with any other price (except for when n=1, then he is indifferent between $P^o = \frac{1}{3}$ and $P^o = \frac{2}{3}$). Moreover, this price always ensures full-subscription and gross proceeds of $\frac{n}{3}$.

Below, we briefly explain the steps taken by Welch to arrive at this conclusion. Firstly, the notation is somewhat different. The positive signal which in Benveniste and Busaba is denoted U, is here denoted H.

$\boldsymbol{P^o > \frac{2}{3}}$**:** No investor will purchase shares, this price cannot be optimal.

$\boldsymbol{\frac{2}{3} \geq P^o > \frac{3}{5}}$: A price within this range creates a negative cascade in the following states: LL, LH and HL (in the HL state, the issuer receives 2/3 from the first investor before a negative cascade occurs). Given that LL, LH and HL are mutually exclusive, and using the highest price in the range (2/3), the issuer's expected proceeds can at most be:

$$E_\pi < prob(LL) * 0 + prob(LH) * 0 + prob(HL) * 1 * \frac{2}{3} + prob(HH) * n * \frac{2}{3}.$$

Using the probabilities Welch derives (prob(LL)=1/3, prob(LH)=1/6, prob(HL)=1/6, and prob(HH)=1/3, we find that the maximum expected proceeds are:

$$E_\pi < \frac{1}{3} * 0 + \frac{1}{6} * 0 + \frac{1}{6} * 1 * \frac{2}{3} + \frac{1}{3} * n * \frac{2}{3} = \frac{1}{9} + \frac{2}{9} * n.$$

For n > 1, the expected proceeds are less than $\frac{n}{3}$ (for n=1, the proceeds are 1/3, meaning that the proceeds lie below 1/3). Thus, an offer price of 1/3 yields higher proceeds than any price in the interval $\frac{2}{3} \geq P^o > \frac{3}{5}$.

$\mathbf{\frac{3}{5} \geq P^o > \frac{1}{2}}$: Given this range, the following states create a negative cascade: LL, LHL and HLL. In the case of HLL, the first investor purchases a share before a negative cascade occurs. Using the highest price in the range (3/5), the expected proceeds are at most:

$$E_\pi < prob(LL) * 0 + prob(LHL) * 0 + prob(HLL) * 1 * \frac{3}{5} + prob\overline{(LL\ v\ LHL\ v\ HLL)} * n * \frac{3}{5},$$

where the strict inequality is justified. In $prob\overline{(LL\ v\ LHL\ v\ HLL)}$ we implicitly exclude negative cascades.

Again, using the probabilities Welch derives (prob(LL)=1/3, prob(HLL)=1/12, and prob(no negative cascades)=1/2), the highest possible proceeds are:

$$E_\pi < \frac{1}{3} * 0 + \frac{1}{12} * 0 + \frac{1}{12} * 1 * \frac{3}{5} + \frac{1}{2} * n * \frac{3}{5} = \frac{1}{20} + \frac{6}{20} * n.$$

For n > 2, the expected proceeds are less than $\frac{n}{3}$ (for n=2, the proceeds are 0.65 and which is less than 2/3). Thus, an offer price of 1/3 yields higher gross proceeds than a price within the range $\frac{3}{5} \geq P^o > \frac{1}{2}$.

$\mathbf{\frac{1}{2} \geq P^o > \frac{2}{5}}$**:** Within this price range, the state LL creates a negative cascade. Using the highest price (1/2), the expected proceeds are at most:

$$E_\pi < prob(LL) * 0 + prob\left(\overline{LL}\right) * \frac{1}{2} * n.$$

Using the probabilities (prob(LL)=1/3, prob($\overline{\text{LL}}$)=2/3), the expected proceeds are:

$$E_\pi < \frac{1}{3} * 0 + \frac{2}{3} * n * \frac{1}{2} = \frac{n}{3}.$$

$\mathbf{\frac{2}{5} \geq P^o > \frac{1}{3}}$**:** Within this price range, the state LLL is enough to create a negative cascade, and using the maximum price of 2/5, the expected proceeds are less than:

$E_\pi < prob(LLL) * 0 + prob(\overline{LLL}) * \frac{2}{5} * n.$

Using prob(LLL)=1/4 and prob($\overline{\text{LLL}}$)=3/4, the maximum proceeds are:

$E_\pi < \frac{1}{4} * 0 + \frac{3}{4} * n * \frac{2}{5} = \frac{3}{10} * n,$

which is lower than n/3. This completes the proof for n≥5. Thus, it shows that no price above 1/3 allows the issuer to obtain higher proceeds for n≥3. For 4≥n≥2, the safe proceeds from $P^o = \frac{1}{3}$ are preferred to any other offer price. For n=1, the issuer is indifferent between a price of 1/3 and 2/3 (recall that from the first equation, $P^o = \frac{2}{3}$ yields: $E_\pi < \text{prob(LL)} * 0 + \text{prob(LH)} * 0 + \text{prob(HL)} * 1 * \frac{2}{3} + \text{prob(HH)} * n * \frac{2}{3} = \mathbf{\frac{3}{n}}$, which is the same proceeds as with $P^o = \frac{1}{3}$).

In our case (Benveniste & Busaba), Q denotes the total shares, thus n=Q, and the expected proceeds are $\frac{Q}{3}$.

1.3. Proof of underpricing.

Welch (1992) defines the average underpricing as the expected value of successful offerings divided by the offer price. From before, he has defined the offer price as:

$p^* = V^L + \frac{V^H - V^L}{3},$

and the expected value is

$EV = V^L + \frac{V^H - V^L}{2}.$

Thus, the underpricing (U) at the optimal price is

$U^* = \frac{EV - P}{P} = \frac{\left[V^L + \frac{V^H - V^L}{2}\right] - \left[V^L + \frac{V^H - V^L}{3}\right]}{\left[V^L + \frac{V^H - V^L}{3}\right]} = \frac{V^H - V^L}{2V^H - 4V^L}.$

Since $0 \leq V^L < V^H$, it follows that $0 < U \leq 0.5$. Thus, the average underpricing lies between 0% and 50%. In our case (Benveniste & Busaba), the underpricing is calculated as EV-P, and thus becomes

$\left[V^L + \frac{V^U - V^L}{2}\right] - \left[V^L + \frac{V^U - V^L}{3}\right] = \frac{V^U - V^L}{6},$

when we are using V^U instead of V^H.

1.4. Proof of theorem 2.

Using the definitions of $\pi_h, \pi'_h,$ and π''_h, Benveniste & Busaba can express:

$$\pi_{h+1} = \frac{H}{2(h+1)}\pi'_h \; and \; \pi_h = \frac{H}{2(H-h)}\pi''_h, \;\; h = 0, \dots, H-1.$$

Under the assumption that no investors reveal positive signals and all investors reveal a negative signal, there will be no allocation of shares ($q_{U,0} = q_{L,H} = 0$). Thus, we can remove $Q\theta_h$from equation (10) (maximization equation):

$$\sum_{h=0}^{H} \pi_h \{Q\theta_h [h q_{U,h} + (H-h) q_{L,h}](\theta_h - P_h^o)\},$$

which appears in the objective function, as

$$\text{(A-1)} \; H \sum_{h=0}^{H-1} \left[\frac{\pi'_h}{2}(\theta_{h+1} - P_{h+1}^o) q_{U,h+1} + \frac{\pi''_h}{2}(\theta_h - P_h^o) q_{L,h}\right].$$

Constraint (8) will hold with equality at the optimum because the underwriter does not have to underprice more than necessary. Substituting (8) into (A-1)

$$\text{(8)} \; \sum_{h=0}^{H-1} \pi'_h [\theta_{h+1} - P_{h+1}^o] q_{U,h+1} \;\geq\; \sum_{h=0}^{H-1} \pi'_h \left[\theta_h - P_h^o + \frac{1}{H+2}\right] q_{L,h},$$

$$H \sum_{h=0}^{H-1} \left[\frac{\pi'_h}{2}(\theta_{h+1} - P_{h+1}^o) q_{U,h+1} \left(\theta_h - P_h^o + \frac{1}{H+2}\right) q_{L,h} + \frac{\pi''_h}{2}(\theta_h - P_h^o) q_{L,h}\right].$$

Simplified,

$$\text{(A-2)} \; H \sum_{h=0}^{H-1} \left[\frac{\pi'_h}{2}\left(\frac{1}{H+2}\right) + \frac{\pi'_h + \pi''_h}{2}(\theta_h - P_h^o)\right] q_{L,h}.$$

(A-2) represents the issuer's expected loss to cheaters or the expected underpricing. Consequently, in order to maximize expected proceeds, the underwriter has to minimize (A-2). To minimize the underpricing, the underwriter should minimize $q_{L,h}$ by setting $P_h^o = \theta_h$whenever $q_{L,h}$ is positive. Substituting the solution from theorem 2 into (A-2) yields the minimum expected underpricing,

$$\text{(A-3)} \; H \left(\frac{1}{2(H+2)}\right) \sum_{h=0}^{Q-1} \pi'_h \left(\frac{Q-h}{H-h}\right).$$

We observe that underpricing only occurs when the number of investors revealing a positive sign is equal to or above the total amount of shares to be allocated ($h = Q, \dots, H$).

The underpricing per share can be written as $u_h = \theta_h - P_h^o$, and thus, the expected underpricing can be expressed as:

(A-4) $Q \sum_{h=Q}^{H} \pi_h u_h = H \left(\frac{1}{2(H+2)}\right) \sum_{h=0}^{Q-1} \pi_h' \left(\frac{Q-h}{H-h}\right)$.

The expected underpricing per share is obtained by dividing through by Q:

$$\boldsymbol{E(u_h) = \sum_{h=Q}^{H} \pi_h u_h = \left(\frac{\sum_{h=0}^{Q-1} \pi_h' \frac{Q-h}{H-h}}{\frac{Q}{H}}\right)\left(\frac{1}{2(H+2)}\right),}$$

which is the expression stated in the theorem (2). Substituting constraint (11) into (10) and dividing by Q yields

$$E(P^o) = \sum_{h=0}^{H} \pi_h \theta_h - \sum_{h=0}^{H} \pi_h (\theta_h - P_h^o),$$

which is the expected proceeds per share.

Given that $\sum_{h=0}^{H} \pi_h \theta_h = \frac{1}{2}$ we can write the first part as ½. Moreover, given that $u_h = \theta_h - P_h^o$ and $E(u_h) = \sum_{h=Q}^{H} \pi_h u_h$, we can simply write the second part as $E(u_h)$. Thus, we obtain the expression for the maximum expected proceeds per share stated in the theorem:

$$\boldsymbol{E(P^o) = ½ - E(u_h).}$$

1.5. Proof of theorem 3.

As we have seen, the marginal value of information (from (5)) expressed in original values is given by $\frac{(V^U - V^L)}{H+2}$, and underpricing per share is $(V^U - V^L)u_h$. Therefore, we can write underpricing as a ratio of the offer price as

$$\frac{u_h}{P_h^o} = \frac{(V^U - V^L)u_h}{V^L + (V^U - V^L)P_h^o}, \qquad h = Q, \dots, H.$$

Since we assume that h is equal to or above Q, the firm will have to underprice the shares and the offer price has to be lower than V^U.

Now, we add a mean-preserving spread to the prior distribution of V by increasing V^U and decreasing V^L by the parameter δ,

$$\frac{u_h}{P_h^o} = \frac{\left((V^U+\delta)-(V^L-\delta)\right)u_h}{V^L-\delta+\left((V^U+\delta)-(V^L-\delta)\right)P_h^o} = \frac{(V^U-V^L)u_h+2\delta u_h}{V^L+(V^U-V^L)P_h^o+\delta(2P_h^o-1)}.$$

Differentiation with respect to δ yields the following expression

$$D_\delta\left(\frac{u_h}{P_h^o}\right) = \frac{2u_h[(V^L-\delta)+[(V^U+\delta)-(V^L-\delta)]P_h^o]-\left[\left((V^U+\delta)-(V^L-\delta)\right)u_h(2P_h^o-1)\right]}{\left[V^L+(V^U-V^L)P_h^o+\delta(2P_h^o-1)\right]^2}$$

$$= \frac{2u_hV^L - 2u_h\delta + 2u_hV^UP_h^o + 2u_h\delta P_h^o - 2u_hV^LP_h^o + 2u_h\delta P_h^o - 2u_hV^UP_h^o + u_hV^U - 2u_h\delta P_h^o + u_h\delta + 2u_hV^LP_h^o - u_hV^L - 2u_h\delta P_h^o + u_h\delta}{[V^L + (V^U - V^L)P_h^o + \delta(2P_h^o - 1)]^2}$$

$$= \frac{2u_hV^L+u_hV^U-u_hV^L}{\left[V^L+(V^U-V^L)P_h^o+\delta(2P_h^o-1)\right]^2} = \frac{2u_hV^L+(V^U-V^L)u_h}{\left[V^L+(V^U-V^L)P_h^o+\delta(2P_h^o-1)\right]^2}$$

$$= \frac{(\boldsymbol{V^U+V^L})\boldsymbol{u_h}}{\left[\boldsymbol{V^L+(V^U-V^L)P_h^o+\delta(2P_h^o-1)}\right]^2}.$$

We observe that the numerator is positive, thus the ratio $\frac{u_h}{P_h^o}$ increases with an increase in δ, i.e. $D_\delta\left(\frac{u_h}{P_h^o}\right) > 0$.

2. Methodology

2.1. List of IPOs in sample

Ticker	Company	IPO date	Simple UP	Adjusted UP	Industry
SKBN	Skandiabanken ASA	02.11.2015	-5.43 %	-7.29 %	Financials
KID	Kid ASA	02.11.2015	-3.55 %	-1.99 %	Consumer Discretionary
EPR	Europris ASA	19.06.2015	0.00 %	-2.68 %	Consumer Discretionary
MULTI	Multiconsult ASA	22.05.2015	18.91 %	18.88 %	Industrials
NANO	Nordic Nanovector ASA	23.03.2015	7.81 %	3.96 %	Health Care
RENO	RenoNorden ASA	16.12.2014	-2.55 %	-0.31 %	Industrials
RAKP	RAK Petroleum plc	07.11.2014	31.21 %	28.63 %	Energy
ENTRA	Entra ASA	17.10.2014	3.08 %	-0.37 %	Financials
XXL	XXL ASA	03.10.2014	6.90 %	5.32 %	Consumer Discretionary
SSO	Scatec Solar ASA	02.10.2014	-0.53 %	0.34 %	Utilities
HYARD	Havyard Group ASA	01.07.2014	-1.49 %	-0.58 %	Industrials
ZAL	Zalaris ASA	20.06.2014	8.70 %	7.90 %	Industrials
AVANCE	Avance Gas Holding Ltd	15.04.2014	0.41 %	-1.59 %	Energy
VARDIA	Vardia Insurance Group ASA	08.04.2014	-15.67 %	-13.94 %	Financials
TIL	Tanker Investments Ltd	25.03.2014	-0.32 %	-2.49 %	Energy
ATLA NOK	Atlantic Petroleum P/F	12.12.2013	-0.71 %	1.17 %	Energy
NAPA	Napatech A/S	06.12.2013	-0.43 %	2.11 %	Information Technology
BWLPG	BW LPG Limited	21.11.2013	4.26 %	4.89 %	Energy
BULKIN	Bulk Invest ASA	25.10.2013	-1.67 %	-2.36 %	Industrials
ODL	Odfjell Drilling Ltd	27.09.2013	-2.38 %	-2.05 %	Energy
OCY	Ocean Yield ASA	05.07.2013	0.00 %	-1.89 %	Energy
ASETEK	Asetek A/S	20.03.2013	-3.33 %	-1.33 %	Information Technology
BRG	Borregaard ASA	18.10.2012	0.00 %	0.06 %	Materials
HLNG	Höegh LNG Holdings Ltd	05.07.2011	0.00 %	-2.52 %	Energy
NRS	Norway Royal Salmon ASA	29.03.2011	0.00 %	-0.89 %	Consumer Staples
GJF	Gjensidige Forsikring ASA	10.12.2010	-0.42 %	0.21 %	Financials
FLOAT	Floatel International Ltd	01.12.2010	-2.14 %	-3.02 %	Energy
MORPOL	Morpol ASA	30.06.2010	-10.45 %	-3.31 %	Consumer Staples
WWASA	Wilh. Wilhelmsen ASA	24.06.2010	-5.37 %	1.20 %	Industrials
BAKKA	Bakkafrost P/f	26.03.2010	0.00 %	-1.89 %	Industrials
BERGEN	Bergen Group ASA	30.06.2008	-6.45 %	-2.18 %	Energy
NPEL	Norway Pelagic ASA	24.06.2008	2.50 %	6.50 %	Consumer Staples
NOR	Norwegian Energy Company ASA	09.11.2007	6.06 %	7.98 %	Energy
NTSG	SpareBank 1 Nøtterøy - Tønsberg	29.10.2007	5.00 %	4.54 %	Financials
PRON	Pronova BioPharma ASA	11.10.2007	3.48 %	3.59 %	Health Care
EMAS	EMAS Offshore Limited	03.10.2007	-4.55 %	-1.15 %	Energy
DOCK	Dockwise Ltd	02.10.2007	0.00 %	0.00 %	Energy
TRI	Tribona ASA	22.06.2007	1.77 %	3.27 %	Financials
GSF	Grieg Seafood ASA	21.06.2007	2.17 %	1.50 %	Consumer Staples
PROTCT	Protector Forsikring ASA	25.05.2007	7.14 %	9.44 %	Financials
MIS	Maritime Industrial Services	22.05.2007	5.00 %	0.92 %	Energy
FOP	Fred. Olsen Production ASA	11.05.2007	-4.62 %	-2.55 %	Energy
SALM	SalMar ASA	08.05.2007	0.00 %	-2.85 %	Consumer Staples
WAVE	Wavefield Inseis ASA	30.03.2007	8.41 %	6.30 %	Energy

NEXUS	Nexus Floating Production Ltd	30.03.2007	1.41 %	0.08 %	Energy
REM	Rem Offshore ASA	30.03.2007	8.75 %	0.76 %	Energy
EMGS	Electromagnetic Geoservices ASA	30.03.2007	7.78 %	7.97 %	Energy
ALGETA	Algeta ASA	27.03.2007	-6.38 %	-5.29 %	Health Care
NEAS	NEAS ASA	23.03.2007	-3.03 %	-4.53 %	Financials
ITX	Intex Resources ASA	21.12.2006	-2.92 %	-5.50 %	Materials
SPITS	Spits ASA	12.12.2006	9.38 %	6.90 %	Consumer Discretionary
FAKTOR	Faktor Eiendom ASA	08.12.2006	-3.43 %	-2.74 %	Financials
NPRO	Norwegian Property ASA	15.11.2006	7.94 %	7.33 %	Financials
DETNOR OLD	Det Norske Oljeselskap	10.11.2006	7.50 %	4.16 %	Energy
AKVA	AKVA group ASA	10.11.2006	0.00 %	0.49 %	Industrials
COD	Codfarmers ASA	19.10.2006	-3.85 %	-2.75 %	Consumer Staples
MAFA	Marine Farms ASA	12.10.2006	-1.43 %	-3.22 %	Consumer Staples
WEIFA	Weifa ASA	07.07.2006	2.42 %	-0.20 %	Health Care
TROLL	Trolltech ASA	05.07.2006	9.38 %	12.37 %	Information Technology
REC	REC Silicon ASA	09.05.2006	23.16 %	23.71 %	Information Technology
DOLP	Dolphin Group ASA	20.04.2006	16.57 %	11.84 %	Information Technology
SBX	SeaBird Exploration PLC	11.04.2006	29.50 %	27.75 %	Energy
BWG	BWG Homes ASA	17.03.2006	11.52 %	12.28 %	Consumer Discretionary
NORD	Norda ASA	14.12.2005	-1.00 %	-1.72 %	Health Care
FUNCOM	Funcom N.V.	13.12.2005	-10.00 %	-12.09 %	Information Technology
GGG	Grenland Group ASA	12.12.2005	30.56 %	25.57 %	Energy
ODIM	Odim ASA	18.11.2005	5.00 %	4.11 %	Industrials
NORGAN	Norgani Hotels ASA	16.11.2005	0.00 %	1.36 %	Financials
BIOTEC	Biotec Pharmacon ASA	04.11.2005	2.04 %	-2.21 %	Health Care
GAS	BW Gas ASA	25.10.2005	-5.49 %	-5.22 %	Energy
CEQ	Cermaq ASA	24.10.2005	0.23 %	-0.81 %	Consumer Staples
POWEL	Powel ASA	24.10.2005	0.00 %	-2.13 %	Information Technology
UNISON	Unison Forsikring ASA	13.10.2005	-0.67 %	0.47 %	Financials
AMSC	American Shipping Company ASA	11.07.2005	1.54 %	-3.96 %	Industrials
WNOR	Wintershall Norge ASA	27.06.2005	4.76 %	5.17 %	Energy
EIOF	Eidesvik Offshore ASA	27.06.2005	11.11 %	11.52 %	Energy
KOA	Kongsberg Automotive ASA	24.06.2005	3.26 %	19.58 %	Consumer Discretionary
VIA	VIA Travel Group ASA	09.06.2005	-1.72 %	-1.31 %	Consumer Discretionary
HFISK	Havfisk ASA	13.05.2005	-0.34 %	0.33 %	Consumer Staples
VIZ	Vizrt Ltd.	12.05.2005	1.37 %	3.27 %	Information Technology
AWO	COSL Drilling Europe AS	11.05.2005	0.00 %	0.18 %	Energy
OSLO	Oslo Areal ASA	03.05.2005	1.89 %	0.37 %	Financials
POLI	Polimoon ASA	26.04.2005	-1.40 %	-3.19 %	Materials
IMAREX	Imarex ASA	04.04.2005	27.16 %	27.22 %	Financials
APL	APL ASA	18.03.2005	16.33 %	16.46 %	Energy
WILS	Wilson ASA	17.03.2005	3.08 %	4.31 %	Industrials
JACK	Petrojack ASA	23.02.2005	1.67 %	2.26 %	Energy
GIG	Gaming Innovation Group Inc	27.01.2005	12.29 %	11.76 %	Information Technology

2.2. Underwriter rank

Rank	Firm	Gross proceeds	Market share	IPO lead
1	ABG Sundal Collier	19 406 901 972	24.09%	19.32 %
2	Goldman Sachs International	18 596 916 755	23.09%	3.41 %
3	SEB Enskilda	11 646 391 053	14.46%	15.34 %
4	UBS	8 357 398 136	10.38%	3.41 %
5	Carnegie	6 855 042 817	8.51%	9.66 %
6	DNB Markets	5 984 484 961	7.43%	13.07 %
7	Pareto Securities	4 477 732 004	5.56%	18.18 %
8	Swedbank	1 521 976 594	1.89%	6.82 %
9	Danske Bank	963 179 507	1.20%	1.14 %
10	Lehman Brothers International	874 412 500	1.09%	1.14 %
11	Arctic Securities	826 800 000	1.03%	1.14 %
12	Nordea	658 853 416	0.82%	1.14 %
13	Fearnley Fonds	173 700 000	0.22%	1.70 %
14	Glitnir Securities	78 000 000	0.10%	1.14 %
15	Alfred Berge	48 044 500	0.06%	0.57 %
16	Orion Securities	38 002 624	0.05%	1.14 %
17	Norse Securities	36 127 700	0.04%	1.14 %
18	Fondsfinans	3 000 000	0.00%	0.57 %

List of all lead underwriters in our sample. The rank is based on the Megginson and Weiss (1991) measure of underwriter quality (market share based on gross proceeds). To the right, we report the fraction of IPOs in which the investment bank acted as the lead underwriter.

3. Analysis and results

3.1. IPO activity and market condition.

Year	Return	Volatility	Number of IPOs	Adj. Underpricing
2005	51.45%	17.48%	25	2.92%
2006	33.02%	24.17%	14	-0.37%
2007	11.92%	19.78%	17	2.76%
2008	-52.61%	46.50%	2	7.85%
2009	47.31%	31.81%	0	NA
2010	13.26%	21.18%	5	2.69%
2011	-9.73%	24.53%	2	8.34%
2012	9.80%	16.61%	1	-5.22%
2013	20.21%	10.38%	7	10.37%
2014	3.13%	14.85%	10	-0.65%
2015	4.25%	17.71%	5	6.12%
Total	**160.86%**	**24.21%**	**88**	**2.87%**

3.2. Correlation matrix

	Return	Volatility	No. IPOs	UP
Return	1			
Volatility	-0.50453	1		
No IPOs	0.466462	-0.3558	1	
UP	-0.39413	0.147607	-0.0724	1

UP in 2009 is set to 0

3.3. Regression (1)

Source	SS	df	MS
Model	1048.09103	6	174.681838
Residual	4837.25706	81	59.719223
Total	5885.34809	87	67.6476792

Number of obs	= 88
F(6, 81)	= 2.93
Prob > F	= 0.0124
R-squared	= 0.1781
Adj R-squared	= 0.1172
Root MSE	= 7.7278

UP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
BB	-3.014215	2.191023	-1.38	0.173	-7.373664	1.345234
VOL	-.2378582	2.106372	-0.11	0.910	-4.428879	3.953162
MRET	.7153444	.2700819	2.65	0.010	.1779662	1.252723
LNREP	.1422351	.1285515	1.11	0.272	-.113542	.3980122
REV	.1307607	.0735648	1.78	0.079	-.0156103	.2771316
HOT	1.823866	2.050768	0.89	0.376	-2.25652	5.904252
_cons	2.492329	3.287384	0.76	0.451	-4.048534	9.033193

Robust standard errors

Linear regression

Number of obs	= 88
F(6, 81)	= 3.00
Prob > F	= 0.0106
R-squared	= 0.1781
Root MSE	= 7.7278

UP	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
BB	-3.014215	2.926359	-1.03	0.306	-8.836752	2.808321
VOL	-.2378582	1.835896	-0.13	0.897	-3.890716	3.414999
MRET	.7153444	.2592642	2.76	0.007	.19949	1.231199
LNREP	.1422351	.16608	0.86	0.394	-.1882121	.4726823
REV	.1307607	.0627476	2.08	0.040	.0059127	.2556086
HOT	1.823866	1.86633	0.98	0.331	-1.889546	5.537278
_cons	2.492329	3.25016	0.77	0.445	-3.974469	8.959127

3.4. Regression (2)

Source	SS	df	MS
Model	1106.43018	9	122.936686
Residual	4778.91792	78	61.2681784
Total	5885.34809	87	67.6476792

Number of obs	= 88
F(9, 78)	= 2.01
Prob > F	= 0.0495
R-squared	= 0.1880
Adj R-squared	= 0.0943
Root MSE	= 7.8274

UP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
BB	-2.578419	2.744355	-0.94	0.350	-8.042011	2.885173
VOL	-.5318947	2.206277	-0.24	0.810	-4.924255	3.860465
MRET	.6576511	.2824495	2.33	0.022	.0953374	1.219965
LNREP	.1621659	.1319374	1.23	0.223	-.1005013	.4248332
REV	.1542371	.0805991	1.91	0.059	-.0062234	.3146975
HOT	2.206177	2.155067	1.02	0.309	-2.084231	6.496585
LNMCAP	-.7185007	1.043122	-0.69	0.493	-2.795198	1.358196
LNAGE	.0086481	.7604577	0.01	0.991	-1.505307	1.522603
LNGP	-.0493349	.9788598	-0.05	0.960	-1.998095	1.899425
_cons	8.428106	14.29951	0.59	0.557	-20.04004	36.89625

Robust standard errors

Linear regression

Number of obs	= 88
F(9, 78)	= 2.43
Prob > F	= 0.0170
R-squared	= 0.1880
Root MSE	= 7.8274

UP	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
BB	-2.578419	3.313106	-0.78	0.439	-9.174306	4.017468
VOL	-.5318947	1.807969	-0.29	0.769	-4.131284	3.067495
MRET	.6576511	.2706095	2.43	0.017	.118909	1.196393
LNREP	.1621659	.1725058	0.94	0.350	-.1812668	.5055986
REV	.1542371	.0697248	2.21	0.030	.0154256	.2930486
HOT	2.206177	1.884861	1.17	0.245	-1.546293	5.958648
LNMCAP	-.7185007	.8357172	-0.86	0.393	-2.382286	.9452845
LNAGE	.0086481	.6647903	0.01	0.990	-1.314848	1.332144
LNGP	-.0493349	.8790713	-0.06	0.955	-1.799431	1.700762
_cons	8.428106	13.17337	0.64	0.524	-17.79807	34.65428

3.5. Regression (3)

Source	SS	df	MS		
Model	1811.75978	26	69.6830685	Number of obs =	88
Residual	4073.58831	61	66.7801363	F(26, 61) =	1.04
				Prob > F =	0.4315
Total	5885.34809	87	67.6476792	R-squared =	0.3078
				Adj R-squared =	0.0128
				Root MSE =	8.1719

UP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
BB	-2.899199	3.145215	-0.92	0.360	-9.188445	3.390048
VOL	.2098451	3.182391	0.07	0.948	-6.153738	6.573428
MRET	.6513626	.4375705	1.49	0.142	-.2236137	1.526339
LNREP	.1132223	.1566521	0.72	0.473	-.2000229	.4264676
REV	.1810574	.0987437	1.83	0.072	-.0163927	.3785076
HOT	1.129634	2.812476	0.40	0.689	-4.49426	6.753527
LNMCAP	-.9644583	1.239878	-0.78	0.440	-3.443748	1.514831
LNAGE	.5602992	.9260332	0.61	0.547	-1.291419	2.412017
LNGP	.5024437	1.208656	0.42	0.679	-1.914413	2.9193
Y2005	2.13717	4.702636	0.45	0.651	-7.266332	11.54067
Y2006	2.800343	5.282293	0.53	0.598	-7.762255	13.36294
Y2007	-1.507947	4.986685	-0.30	0.763	-11.47944	8.463547
Y2008	3.378577	8.53885	0.40	0.694	-13.69591	20.45306
Y2010	-2.255178	6.035188	-0.37	0.710	-14.32328	9.812926
Y2011	1.775847	7.7303	0.23	0.819	-13.68184	17.23354
Y2012	9.63456	11.1096	0.87	0.389	-12.58046	31.84958
Y2013	-3.10476	5.422029	-0.57	0.569	-13.94678	7.737258
Y2014	1.485568	5.103531	0.29	0.772	-8.719573	11.69071
OSE10	-4.413311	10.22854	-0.43	0.668	-24.86655	16.03993
OSE15	-17.12402	11.93324	-1.43	0.156	-40.98601	6.737964
OSE20	-6.517516	10.20585	-0.64	0.525	-26.92537	13.89033
OSE25	-4.075747	10.07089	-0.40	0.687	-24.21373	16.06224
OSE30	-8.963075	10.76541	-0.83	0.408	-30.48985	12.5637
OSE35	-9.541646	10.86689	-0.88	0.383	-31.27134	12.18804
OSE40	-6.478012	10.2745	-0.63	0.531	-27.02314	14.06712
OSE45	-4.830945	10.48356	-0.46	0.647	-25.79412	16.13223
_cons	3.886915	21.51909	0.18	0.857	-39.14316	46.91699

Robust standard errors

Linear regression

Number of obs	= 88
F(24, 61)	= .
Prob > F	= .
R-squared	= 0.3078
Root MSE	= 8.1719

UP	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
BB	-2.899199	3.604424	-0.80	0.424	-10.10669	4.308293
VOL	.2098451	3.563506	0.06	0.953	-6.915825	7.335515
MRET	.6513626	.4101728	1.59	0.117	-.1688286	1.471554
LNREP	.1132223	.186272	0.61	0.546	-.2592515	.4856962
REV	.1810574	.0895875	2.02	0.048	.0019161	.3601987
HOT	1.129634	2.505625	0.45	0.654	-3.880673	6.13994
LNMCAP	-.9644583	1.113323	-0.87	0.390	-3.190686	1.26177
LNAGE	.5602992	.7525454	0.74	0.459	-.9445084	2.065107
LNGP	.5024437	1.196142	0.42	0.676	-1.88939	2.894277
Y2005	2.13717	6.456887	0.33	0.742	-10.77417	15.04851
Y2006	2.800343	6.522282	0.43	0.669	-10.24177	15.84245
Y2007	-1.507947	6.638712	-0.23	0.821	-14.78287	11.76698
Y2008	3.378577	9.634251	0.35	0.727	-15.8863	22.64345
Y2010	-2.255178	7.025269	-0.32	0.749	-16.30307	11.79272
Y2011	1.775847	7.514472	0.24	0.814	-13.25027	16.80196
Y2012	9.63456	7.430949	1.30	0.200	-5.224541	24.49366
Y2013	-3.10476	6.499164	-0.48	0.635	-16.10064	9.891122
Y2014	1.485568	7.026239	0.21	0.833	-12.56427	15.5354
OSE10	-4.413311	6.182216	-0.71	0.478	-16.77542	7.948795
OSE15	-17.12402	6.989822	-2.45	0.017	-31.10104	-3.147009
OSE20	-6.517516	5.178615	-1.26	0.213	-16.8728	3.837765
OSE25	-4.075747	5.559782	-0.73	0.466	-15.19322	7.041724
OSE30	-8.963075	6.293609	-1.42	0.159	-21.54792	3.621775
OSE35	-9.541646	6.509181	-1.47	0.148	-22.55756	3.474265
OSE40	-6.478012	6.37159	-1.02	0.313	-19.21879	6.262769
OSE45	-4.830945	7.04772	-0.69	0.496	-18.92373	9.261842
_cons	3.886915	21.76951	0.18	0.859	-39.64392	47.41775

4. Econometric issues

4.1.Testing for functional form misspecification

```
    Ramsey RESET test using powers of the fitted values of UP
           Ho:  model has no omitted variables
                      F(3, 75) =      1.77
                      Prob > F =      0.1601
```

Manual test for misspecification (RESET test)

```
. predict yhat
(option xb assumed; fitted values)
(1 missing value generated)

. gen yhatsq=yhat^2
(1 missing value generated)

. gen yhatcub=yhat^3
(1 missing value generated)

. reg up bb vol1m rw lnurgp rev hot lnmcap lnage lngp yhatsq yhatcub

 test yhatsq yhatcub

( 1)  yhatsq = 0
( 2)  yhatcub = 0

       F(  2,    76) =    2.10
            Prob > F =    0.1291
```

4.2.Testing for heteroscedasticity

Whites test (imtest)

```
Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	58.22	52	0.2573
Skewness	14.44	9	0.1075
Kurtosis	6.81	1	0.0091
Total	79.46	62	0.0668

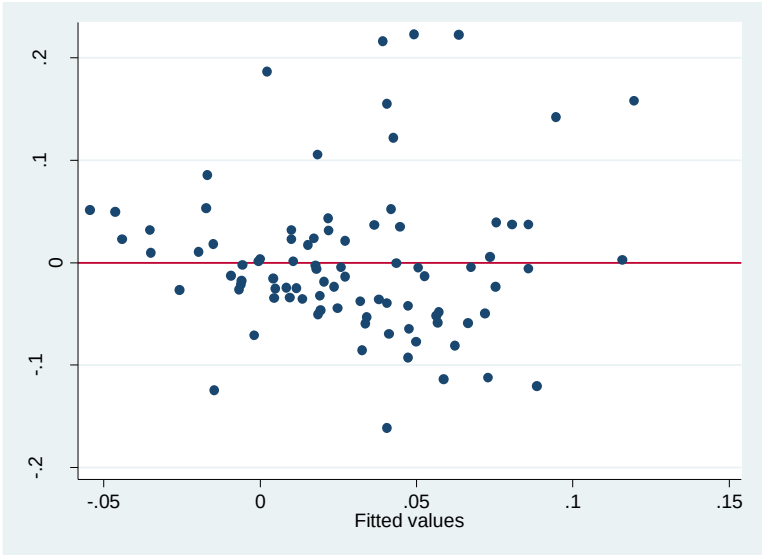
Breusch-Pagan test (hettest)

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of up

         chi2(1)      =     9.48
         Prob > chi2  =   0.0021
```

Breusch-Pagan test (manual)

```
. predict uhat, resid
(1 missing value generated)

. gen uhatsq=uhat^2
(1 missing value generated)

. reg uhatsq bb vol1m rw lnurgp rev hot lnmcap lnage lngp


. scalar LM=e(r2)*e(N)

. scalar pvalue=chi2tail(e(df_m),LM)

. disp "Breusch-Pagan test: LM = " LM ", p-value = " pvalue
Breusch-Pagan test: LM = 8.7460812, p-value = .4610357
```

Scatterplot of residuals from regression (2)



4.3. Testing for multicollinearity

Correlation matrix for explanatory variables

	bb	vol1m	rw	lnurgp	rev	hot	lnmcap	lnage	lngp
bb	1.0000								
vol1m	-0.0627	1.0000							
rw	-0.1215	-0.2728	1.0000						
lnurgp	0.3099	0.0371	-0.0264	1.0000					
rev	-0.0680	-0.0056	0.1819	0.0358	1.0000				
hot	0.1734	0.1932	-0.2499	0.2747	0.0580	1.0000			
lnmcap	0.2433	-0.0384	-0.1804	0.2551	0.2526	0.2811	1.0000		
lnage	0.0326	0.0309	-0.1127	0.0870	-0.1482	0.1038	0.1693	1.0000	
lngp	0.5522	-0.1180	-0.2254	0.2975	0.1553	0.3509	0.7212	0.3044	1.0000

Vol1m refers to VOL, rw refers to MRET and lnurgp refers to LN(REP).

Variance Inflation Factor (VIF)

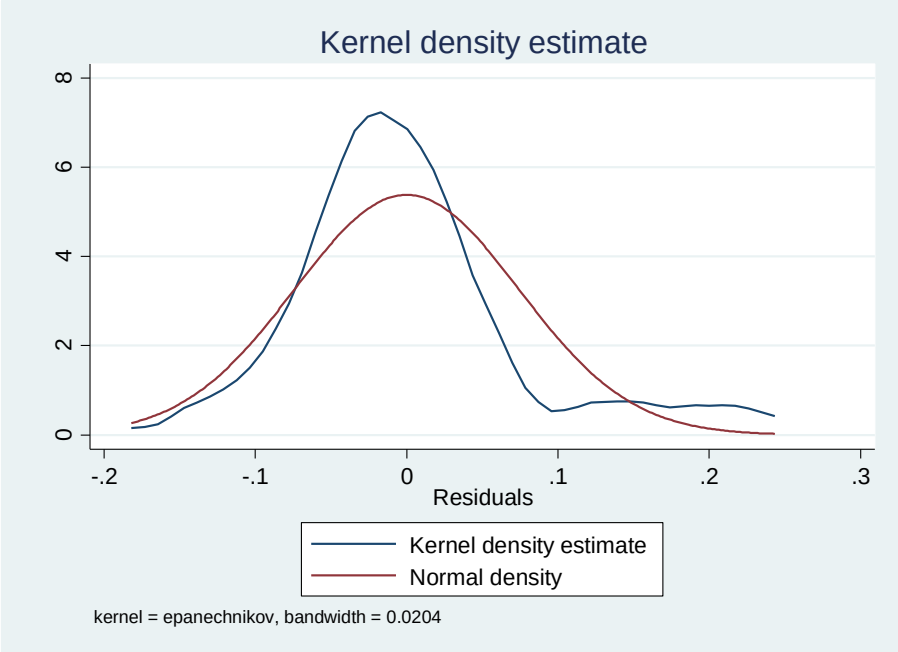
Variable	VIF	1/VIF
lngp	3.79	0.263522
lnmcap	2.38	0.420434
bb	1.76	0.568154
hot	1.29	0.776524
rw	1.27	0.784617
lnage	1.23	0.811115
rev	1.23	0.812008
lnurgp	1.21	0.825694
vol1m	1.20	0.835921
Mean VIF	1.71	

4.4. Dropping influential variables

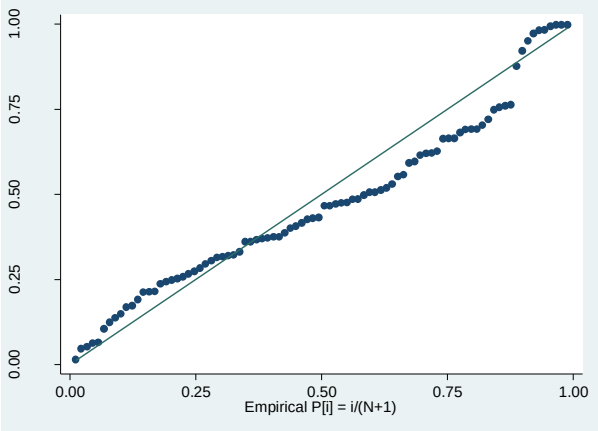
Variables	Regular standard errors			Robust standard errors		
	Original	Dropped 5	Dropped 10	Original	Dropped 5	Dropped 10
Intercept	8.428	-1.42	6.682			
	(0.59)	(-0.12)	(0.66)	(0.64)	(-0.12)	(0.74)
BB	-2.578	-0.0444	-0.243			
	(-0.94)	(-0.02)	(-0.12)	(-0.78)	(-0.02)	(-0.12)
VOL	-0.5312	-0.5347	-2.2275			
	(-0.24)	(-0.29)	(-1.35)	(-0.29)	(-0.29)	(-1.76)*
MRET	0.6577	0.6786	0.4769			
	(2.33)**	(2.85)***	(2.32)**	(2.43)**	(2.9)***	(2.57)**
LN(REP)	0.1622	0.0389	-0.0344			
	(1.23)	(0.34)	(-0.35)	(0.94)	(0.3)	(-0.35)
REV	0.1542	0.2147	0.1551			
	(1.91)*	(2.59)**	(2.22)**	(2.21)**	(2.74)***	(2.44)**
HOT	2.206	2.363	2.06			
	(1.02)	(1.28)	(1.3)	(1.17)	(1.31)	(1.56)
LN(MCAP)	-0.719	-0.693	-0.718			
	(-0.69)	(-0.81)	(-0.97)	(-0.86)	(-0.83)	(-1.08)
LN(AGE)	0.0086	0.289	-0.002			
	(0.01)	(0.46)	(0)	(0.01)	(0.48)	(-0.01)
LN(GP)	-0.0493	0.335	0.085			
	(-0.05)	(0.42)	(0.12)	(-0.06)	-0.42	(0.14)
Obs	88	83	78			
R-squared	18.8%	26.1%	24.0%			
Adj. R-squared	9.4%	17.0%	13.9%			
F-value	(2.01)**	(2.86)***	(2.39)**			

4.5. Testing for normality of residuals

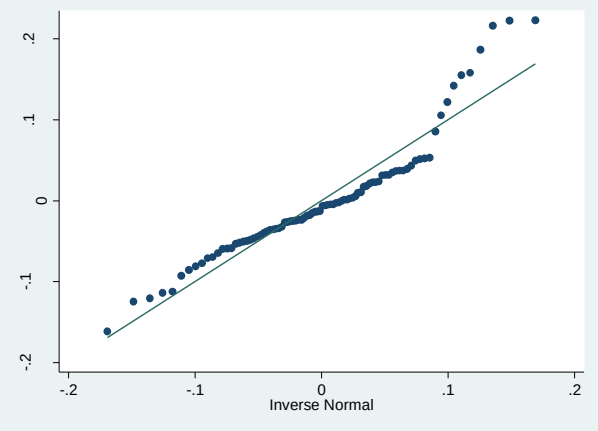
Kernel density estimate



P-P plot



Q-Q plot



Inter-quartile range (IQR) test

```
   mean= -7.2e-11          std.dev.=   .0741          (n= 88)
 median= -.0095    pseudo std.dev.=   .0555        (IQR=  .0749)
10 trim=  -.008

                                          low         high
                                    -------------------
                         inner fences   -.1559        .1438
                  # mild outliers       1           6
                  % mild outliers       1.14%       6.82%

                         outer fences   -.2683        .2562
                  # severe outliers     0           0
                  % severe outliers     0.00%       0.00%
```

Jarque-Bera skewness/kurtosis test for normality

Skewness/Kurtosis tests for Normality

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	joint adj chi2(2)	joint Prob>chi2
r	88	0.0002	0.0118	16.19	0.0003

Shapiro-Wilk W test for normal data

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r	88	0.91360	6.415	4.094	0.00002

4.6. Testing for normality of residuals without the 10 most influential observations