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Economics

IPO Underpricing in the US

The impact of Information Asymmetry on Today's IPO Market

Author: L. Croes

Student ID Number: 410090

Supervisor: Dr. J. Lemmen

Second Assessor: Dr. M. Montone

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Preface and acknowledgements

Before you lies the dissertation “IPO underpricing in the US”, which is a thesis that investigates the effect of information asymmetry on IPO underpricing in the US. This is the final project of my bachelor Economics and Business Economics at the Erasmus University Rotterdam. During this bachelor, I did not only learn about economics in the broad sense, but also about financial economics specifically through the electives and major I have chosen. Writing this thesis was an extension of previous months in which I gained substantially deeper insights in the sector of financial economics, which I believe will be a perfect preparation for my master Financial Economics at the Erasmus economics.

However, conducting this study would not be possible without the people who supported me. At first, I would like to thank my supervisor Dr. J. Lemmen for his guidance, advice, and flexibility during my bachelor thesis. His expertise and experience in financial economics and as supervisor were helpful during this process. Besides I would like to thank all other related parties that made it possible to finalize this study.

Abstract

This paper investigates the existence of short-term IPO underpricing in today's market and the effect of information asymmetry on the level of underpricing. The average first-day return on initial public offerings (IPOs) was 36% in 1998, before peaking at 74% during the internet bubble years of 1999-2000. After the burst of the internet bubble the average first-day returns dropped to slightly less than 15% during 2001-2009 and increased to approximately 20% for the period of 2010-2017. About 30% of the changes in the level of underpricing from 2001-2017 can be attributed to information asymmetry, which is substantially lower than during the internet bubble. These results are in line with the findings that explanations for underpricing vary over time and with environmental factors.

JEL Classifications: G24, G32

Keywords: IPOs, first-day returns, information asymmetry, venture capital, underwriter reputation, financial ratios

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1 Introduction

Last decades there is a lot more media coverage of companies that decide to go public, especially since the internet bubble of 1999-2000 and the occurrence of the technology bubble recently. A company can decide to go public through an initial public offering (IPO). An IPO is the process where the stock of a private company is offered to the public for the first time. Companies may decide to go public for various reasons despite the substantial costs related to this process. One of the primary reasons for firms to go public is the amount of capital raised through the IPO. This additional capital generated through the offering could serve to fund capital expenditures, research and developments (R&D), or pay of existing debt for instance. The prestigious reputation related to publicly listed firms and the increased public awareness generated through the process of going public are perceived as two major advantages by most issuers. In general, there are two different types of companies distinguishable that decide to go public. Specifically, we can observe either young and small companies which intend to acquire additional capital to fund their growth or large privately-owned companies, who desire to become publicly listed. IPOs could serve as exit strategies for co-founders, like venture capitalists for example. They use the funds generated through the IPO to cash out on nowadays successful firm they funded as start-up. However, deciding to take a company to the public can bring disadvantages along too, like stricter regulations, disclosure of information, and costs related to the IPO process.

As documented by existing literature the following three anomalies are observed regarding IPOs: short-term underpricing, cyclicity in underpricing, and long-term underperformance. In this study, I will investigate the short-term underpricing in the United States (US) for today's market. Data on 1528 US IPOs from 1998 till 2017 will be used to conduct this research. I was intrigued to investigate the short-term underpricing puzzle, because even though its existence has been documented over 30 years ago there is still a lot of argument and commotion regarding this anomaly these days. Especially since the occurrence of the internet bubble in 1999 and its burst in May 2000. This period resulted in extensive academic debate about the pricing of IPOs. Today there is a lot of academic and media attention regarding IPOs and the short-term underpricing anomaly due to the existence of a technology bubble. The S&P 500 Information Technology Index, which incorporates the developments in stock price for the 60 largest technology firms in the US, has peaked Wednesday the 19th of July 2017 at an all-time high 992.29. Therewith rising above its previous peak of 988.49 set approximately 17 years ago just before the burst of the internet bubble. These developments in the technology sector are confirmed by the immense scope of recent IPOs like Snapchat, Facebook, and Alibaba Group Holding. The IPO of Alibaba Group Holding, a Chinese company operating in the e-commerce sector,

on the New York Stock Exchange (NYSE) in September 2014 was the largest IPO raising approximately 21.77 billion US $.

These high first-day returns are observed repeatedly over time on various stock markets and different countries. From now on first-day returns will be used interchangeably with underpricing through the paper. An average first-day return of approximately 15% has been documented in the US from 2001-2010 (Loughran & McDonald, 2013). Although the majority of studies is in accordance with confirming the existence of the underpricing anomaly in various markets over time, there is a discrepancy between the explanations for the level of underpricing mentioned in existing literature. Led by the belief of Loughran and Ritter (2002a) that reasons for the level of underpricing change over time and through environmental factors, this paper aims to investigate the role of information asymmetry in explaining the level of underpricing in the US from 2001 till 2017. The research question of this paper is therefore as follows:

What is the impact of information asymmetry on the underpricing of US IPOs?

I will attempt to answer this research question by obtaining deeper insights in the underpricing anomaly through an extensive analysis. By means of inferences from this research I intend to provide more clarity whether theories regarding information asymmetry are a proper explanation of the level of underpricing these days in the US IPO market. The paper is structured as follows. First, I will look in more detail what the short-term underpricing anomaly is. Existing literature provides a lot of different theories as explanation for the changes in the level of underpricing, so in the literature review in the next chapter the most important theories will be discussed. The data section in chapter three will provide deeper insights in the process of gathering the data and the definition of important variables. The fourth chapter concerns the methodology of this research. The results are presented in the fifth chapter together with the forthcoming acceptation or rejection of the hypotheses. In chapter 6 I will discuss the results and in chapter 7 an overall conclusion will be made based on these results. In this conclusion, I will intend to provide a clear answer to the research question. Finally, the limitations of this research and recommendations for further research will be provided in chapter eight.

2 Literature Review

2.1 The IPO Process

An extensive amount of research on various fields regarding to IPOs has been conducted since the late 1980s. For convenience purposes, I will first elaborate quickly on the IPO process and the underpricing anomaly before the existing literature on IPO underpricing will be discussed in more detail. After a firm decides to go public it obtains the assistance of an underwriter, which will be an investment bank in

most cases. In most of the IPOs additional underwriters are appointed to form a syndicate. The underwriter helps the issuer to determine the optimal offer price, the amount of shares to be issued, the timing of the offering, and what type of security to offer. First, the underwriter will acquire various sorts of information regarding the issuer's firm, like financial performance and expected future operations. An overview of this information be part of the prospectus, which is filed with the Securities and Exchange Commission (SEC). The SEC is an independent agency of the US federal government, which is primary responsible for enforcing the federal securities laws, proposing security rules, and regulating the securities industry. Second, the underwriter syndicate may choose to conduct a road show. At a road show the underwriters visit prospective investors, like fund managers for instance, to generate interest and excitements in the IPO. This method is generally used to estimate demand for the IPO. Thereafter, the underwriters will determine the offer price in accordance with the company's board of directors.

2.2 The Underpricing Anomaly

The underpricing anomaly is the pricing of an IPO below its market value. The first-day returns are computed as the percentage change between the first-day closing price and the offer price, which results in the following formula:

$$First - Day\ Returns = \frac{Closing\ Price - Offer\ Price}{Offer\ Price} \quad (1)$$

Many researchers have documented that the share price in an IPO tends to jump substantially on the first trading day. They documented that the first-day closing price is substantially higher than the offer price at the IPO, so consequently IPOs exhibit positive first-day returns on average irrespectively of the period, country, and industry of the IPO. This phenomenon is called underpricing, because it describes the additional amount of proceeds which could have been generated by the IPO if the offer price had been set at an appropriate level. In the next section, I will review the empirical evidence of this underpricing anomaly documented by existing literature.

2.3 Empirical Evidence

In this section, I will discuss the empirical evidence reported by various researchers in their studies. Table 1 on the following page provides an overview of every paper discussed at the literature review for convenience purposes. One of the first to report the underpricing anomaly was Ibbotson (1975) and Ibbotson and Jaffe (1975). Ibbotson documents average initial performance of approximately 11% in the US from 1960 till 1969. An average first-month return of approximately 17% relative to the market was found by Ibbotson and Jaffe in the US during the 1960s, which was caused by the "hot issue" phenomenon according to them. Ibbotson et al. (1994) found an average first-day return of 10-

15% in the US from 1960 till 1992. Average underpricing of approximately 21% has been observed in the 1960s, 9% in the 1970s, 15% in the 1980s, and 10% from 1990 till 1992. Loughran and Ritter (2002a) reported an average first-day return of 18.9% in the US from 1980 till 2000. They observed an average underpricing of approximately 7% in the 1980s, 15% in the 1990s, and 65% during the internet bubble. Loughran and McDonald (2013) documented an average first-day return of 34.8% from 1997 till 2010. Loughran and Ritter (2002b) analyzed underpricing in 25 countries ranging from well-developed markets, emerging markets, to undeveloped markets and observed underpricing in all countries. This implies that underpricing is a worldwide observed anomaly. Ljungqvist (1997) found average first-day returns of 9.2% in Germany from 1970-1993 for instance. Chan et al. (2004) observed average first-day returns for A-class and B-class shares of 178% and 11.6% respectively from 1993-1998 for example. Although all these studies are in accordance on the existence of underpricing there is a discrepancy in theories appointed as explanations for the level of underpricing. Therefore, the most important theories mentioned as explanation for the degree of underpricing in existing literature will be discussed in the next section.

Table 1: Overview of papers discussed at the literature review by author(s), publication year, and title.

Author(s)	Year	Title
Barron	1982	A Model of the demand for investment banking advising and distribution services for new issues
Beatty & Ritter	1986	Investment banking, reputation, and the underpricing of initial public offerings
Berk & DeMarzo	2014	Corporate Finance
Boubaker & Mezhoud	2011	Impact of managerial ownership on operational performance of IPO firms: French context
Bundoo	2007	An analysis of IPOs underpricing in Mauritius
Carter, Dark & Singh	1998	Underwriter reputation, initial returns, and the long-run performance of IPO stocks
Carter & Manaster	1990	Initial public offerings and underwriter reputation
Chan, Wang & Wei	2004	Underpricing and long-term performance of IPOs in China
Grinblatt & Hwang	1989	Signaling and the pricing of new issues
Ibbotson	1975	Price performance of common stock new issues
Ibbotson & Jaffe	1975	“Hot issue” markets
Ibbotson, Sindelar & Ritter	1994	The market’s problems with the pricing of initial public offerings
Ljungqvist	1997	Pricing initial public offerings: Further evidence from Germany
Loughran & Ritter	2002a	Why has IPO underpricing changed over time?
Loughran & Ritter	2002b	Why don’t issuers get upset about leaving money on the table in IPOs?
Loughran & McDonald	2013	IPO first-day returns, offer price revisions, volatility, and form S-1 language
Miller & Reilly	1987	An examination of mispricing, returns, and uncertainty for initial public offerings
Michaely & Shaw	1994	The pricing of initial public offerings: Tests of adverse-selection and signaling theories
Ritter	1984	The “hot issue” market of 1980
Rock	1986	Why new issues are underpriced
Welch	1989	Seasoned offerings, imitation costs, and the underpricing of initial public offerings

2.4 Theories on Underpricing

Existing literature has provided several well-known theories that are supposed to explain the level of underpricing in the specific paper. Therefore, I will review a range of important models regarding the regarding the explanation of the high average first-day returns. A dominant factor in these explanatory theories is information asymmetry, which comes in various forms. Information asymmetry can exist between investors, underwriters, issuers and investors, and investors and underwriters. Asymmetric information is present whenever one party involved with the IPO has superior knowledge relatively to the other party. The different types of information asymmetry between various participant will be discussed separately.

2.5 Information Asymmetry Between Investors

This theory assumes there is information asymmetry between two groups of investors, the informed and the uninformed investors (Rock, 1986). The informed investors, mostly institutional investors, have superior knowledge regarding the intrinsic value of the shares and the prospect of the firm, which causes this group of investors to only participate and acquire undervalued shares. In contrast, the uninformed will participate in all IPOs and mostly acquire overvalued shares through the winner's curse phenomenon. If all market participants are rational uninformed investors will require compensation for this allocation disadvantage. Therefore, underpricing is required to encourage uninformed investors to participate in the IPOs (Berk & DeMarzo, 2014; Michaely & Shaw, 1994). Beatty and Ritter (1986) present the theory that the level of underpricing is related to ex ante uncertainty, which is an expansion of Rock's previously mentioned model. When a company's value and prospects are uncertain the IPO tends to be riskier, especially for uninformed investors. These investors require composition for this riskiness of the IPO through increased underpricing.

2.6 Information Asymmetry Between Issuers and Investors

The signaling theory is based on information asymmetry between the issuer and investor, whereby the issuer has superior knowledge about the company's value and prospects relatively to the investors (Welch, 1989). This theory states that the issuer wishes to leave a positive impression behind at the investors after the IPO through a certain level of underpricing to ensure the success of future equity offerings (Ibbotson & Jaffe, 1975; Welch, 1989). According to most signaling models there are two types of companies distinguishable: low quality and high quality firms. High imitation costs cause signaling costs to be higher for the low quality firms. This model has been expanded by including the variance of a project's cash flow, where the offer price represents the true value of a firm (Grinblatt & Hwang, 1989). According to their findings is the intrinsic value of the firm positively correlated to the level of underpricing. The issuer will initially conduct a partial offer, whereby he will suffer the cost of

underpricing in order to reveal the true quality of the firm through the information creation. Low quality firms will not imitate these high quality firms, because the marginal costs are substantial for these firms and they potentially risk exposing the low quality of the firm over time. However, not some other findings do not seem to be in line with these findings. For instance, Michaely and Shaw (1994) stated that a higher level of underpricing implies a lower chance of a follow up through a Seasoned Equity Offering (SEO).

2.7 Information Asymmetry Between Underwriters and Investors

Baron's (1982) model assumes that the underwriter has superior information with respect to markets demand for the IPO relatively to the issuer and that the firm commitment contract is not optimal. The underwriter will therefore try to minimize their risks and distribution efforts. This is a typical principle-agent problem, since the underwriter aims to pursue his own goal at the expense of the issuer, which leads the lower proceeds. Issuers will try to decrease the level of underpricing by minimizing their firm's ex ante uncertainties, since a certain degree of underpricing is already induced by underwriters. Loughran and Ritter (2002b) documented that the marketing of an IPO is less costly for underwriters if the IPO is underpriced.

Another important expansion from Rock's model is model from Carter and Manaster (1990), which focusses on information asymmetry reciprocally between underwriters. They state that investors have scarce resources to obtain information, which causes informed investors to mainly focus on risky IPOs. This in term leads to risky IPOs being underpriced more heavily on average. Issuers of low-risk IPOs wish to reveal their relatively low risk by appointing prestigious underwriters, since underpricing is perceived as costly by the issuer. Prestigious underwriters will in turn only be willing to market low-risk IPOs in order to maintain their prestigious reputation. Due to these patterns, low-risk IPOs are mainly associated to prestigious underwriters over time, which reduces the investors motivation to acquire information regarding the IPO. Diminishing the information asymmetry between informed and uninformed investors.

2.8 Hypotheses

To investigate whether these theories will hold I will analyze the relationship between several proxies of information asymmetry and the degree of underpricing. As been discussed in the previous section existing literature has provided empirical evidence between information asymmetry and underpricing in various ways. Based on these theories I will investigate the relationship between the following proxies for information asymmetry and underpricing.

2.8.1 Company Age

As been mentioned before Beatty and Ritter (1986) state that there is a relationship between ex ante uncertainty and underpricing. Since the valuation and prospects of young firms are more uncertain they are perceived as riskier by investors, which causes their IPOs to be underpriced more heavily. Therefore, the third hypothesis is as follows:

Hypothesis 1: The age of the company is negatively related to the level of underpricing

2.8.2 Underwriter Prestige

Prestigious underwriters are better in efficiently estimating the offer price and attracting investors for the long term. Carter & Manaster (1990) provide a useful index for to determine underwriter prestige as well as valuable insights implying that prestigious underwriters are associated with less risk and reduced underpricing. Besides, prestigious underwriters have respectable clienteles that include long-term investors, which contribute to the long-term performance after an IPO (Carter, Dark & Singh, 1998). Loughran and Ritter's (2002a) findings state that underwriters leave money on the table on purpose and create an allocation bias by favoring buy-side investors. Michaely and Shaw (1994) used the underwriter's capital and market share as proxy for underwriter reputation and their findings confirm the previously found relationship between underwriter prestige and the degree of underpricing. This leads to the following hypothesis:

Hypothesis 2: The underwriter prestige is negatively related to the level of underpricing

2.8.3 Venture Capital Backing

Multiple findings in existing literature have shown that VC backing of a firm at the time of the offering led to the IPO being more heavily underpriced (Loughran & Ritter, 2002a; Loughran & McDonald, 2013). The next hypothesis is as follows:

Hypothesis 3: Venture capital backing at time of the offering is positively related to the level of underpricing

2.8.4 Positive Price Revision

Loughran and Ritter (2002a) found a positive relationship between the upward offer price revision and the level of underpricing. Therefore, the following hypothesis is formulated:

Hypothesis 4: The upward offer price revision is positively related to the level of underpricing

2.8.5 Issue Size

Carter and Manaster (1990) find that the issue size is negatively related to standard deviation of the first-day returns. Moreover, they state that investors take the issue size into account when they value

an IPO. Miller and Reilly's (1987) findings imply that the uncertainty on new equity offerings is represented by issue size. They state that older and lager firms are associated with larger IPOs, which reduces the risk perceived by investors. Leading to large IPOs generally being less underpriced. Based on these findings the first hypothesis is as follows:

Hypothesis 5: The issue size of an IPO is negatively related to the level of underpricing

2.8.6 Market Capitalization

Market capitalization can be used to signal the investors about the firm's quality (Boubaker & Mezhoud, 2011). According to Bundoo (2007) are large firms more heavily underpriced than small firms, which leads to the following hypothesis:

Hypothesis 6: Market capitalization is positively related to the level of underpricing

2.8.7 Period of the IPO[1]

A hot issue market refers to a period in which there is a high volume of IPOs with strong underpricing in a specific factor (Ritter, 1984). Therefore, the level of underpricing of an IPO can be dependent on the period in which the firm decides to go public. Ibbotson and Jaffe's (1975) findings imply the cyclicity of the degree of underpricing. According to Loughran and Ritter (2002b) the reasons for underpricing differ over time. Therefore, the last hypothesis is as follows:

Hypothesis 7: There is a relationship between the period of the IPO and the level of underpricing

3 Data

This chapter elaborates on the data sources used in my research, the process of gathering the data, and an explanation on several key variables. The primary data source is the financial database ThomsonOne (T1). This database collects financial data from annual reports, as well as data about mergers, acquisitions, and IPOs. ThomsonOne focusses mainly on listed companies worldwide.
The following advanced search criteria have been set to generate the sample of IPOs:

1) The first trading date of the IPO was between 1-1-1998 and 30-6-2017.
2) The issuer's primary line of business is based in the US.
3) The issuer is not listed at any other market at the time of the offering.
4) The security type is common stock.
5) The offering technique is firm commitment, accelerated book building, intermediaries offer, block trade or negotiated sale.
6) Issuers primary operating in the utilities, financial, government and agencies, healthcare or real estate sector are excluded.

[2]A more detailed explanation and the link to the webpage is provided in appendix 2.

The first requirement is to ensure only IPOs for the period of interest in this research are included. The second criterion makes sure only US based companies are included in the sample, since this study focusses on US oriented firms. The third requirement excludes all IPOs, whereof the issuer's stock currently already trades at another market. Therefore, only the so called "Original IPOs" are included. The fourth criterion ensures that only offerings of common stock are included, since this is the security type I am interested in. Therefore, other security types, like preferred or convertible stock for instance, are excluded from the sample. The fifth requirement makes sure only common offering techniques are included based on existing literature. Consequently, the best efforts offering technique has been excluded for example, since this type of offerings are typically small offerings. The last criterion serves to exclude all irrelevant industries for this research based on ThomsonOne's macro level industry classifications. This resulted in a sample of 1883 IPOs from 1998 till 2017. The prestige of underwriters is determined by using the dataset on IPO Underwriter Reputation Rankings (1980-2015) obtained from professor Jay Ritter's webpage[2]. Assuming the underwriter ranking remains unchanged for IPOs that took place after 2015.

However, transformations and corrections had to be conducted to the generated dataset in order to make it more appropriate for this research. Several IPOs were missing values for key variables in this study, like the offer price, first-day closing price, and the primary exchange for instance. First, IPOs with an offer price below $5.00, called Penny stocks, are excluded from the dataset. Penny stocks are shares that trade at a relatively low price outside of major exchanges and have a small market capitalization. Therefore, these stocks are usually of little interest for institutional investors. Second, every IPO with an uncommon security type that managed to slip through the advanced search criteria has been removed. Typically, these were uncommon alternatives like interest or debt related shares. Last, all offerings that were not primary listed on the New York Stock Exchange (NYSE), National Association of Securities Dealers Automated Quotation (NASDAQ), and the former American Stock Exchange (AMEX) are excluded from the sample. These additional data transformations resulted in the exclusion of 320 IPOs from the original dataset, so a sample of 1528 IPOs from 1998 till 2017 remains. In the next section, I will provide a more detailed description of key and/or explanatory variables from this study.

3.1 Variable Description

To investigate these theories of information asymmetry as explanation for variation in underpricing they should be properly represented by economic variables that serve as proxies. This section will describe the interpretation and measurement of these key variables.

[2]A more detailed explanation and the link to the webpage is provided in appendix 2.

The first-day return is the dependent variable in this study, which indicates whether the IPO is underpriced or not. The first-day return is computed as the percentage change from the offer price to the first-day closing price:

$$First - Day\ Returns = \frac{Closing\ Price - Offer\ Price}{Offer\ Price} \quad (1)$$

This is the most common way to identify underpricing according to the existing literature (Loughran & McDonald, 2013). A further definition of the independent variables of the multivariate regression is provided in table 2. Key variables of the univariate sorts have been further defined in table 3 in the appendix.

Table 2: The interpretation and measurement of the independent variables of the multivariate regression.

Variable	Interpretation and Measurement
Company Age	The age of the company at the time of going public, measured by subtracting the founding year from the IPO year. The natural logarithm was used at the multivariate regression analysis.
Negative Price Revision	The variable takes up the value if the offer price is revised downwards relatively to the midpoint of the official file price range. The value of zero is assigned in case of a positive price revision.
Positive Price Revision	The variable takes up the value if the offer price is revised upwards relatively to the midpoint of the official file price range. The value of zero is assigned in case of a negative price revision.
Issue Size	The number of shares offered in all markets multiplied by the offer price. The natural logarithm is used at the multivariate regression analysis.
Market Capitalization	The number of shares offered in all markets multiplied by the first-day closing price. The natural logarithm is used at the multivariate regression analysis.
Dummy Variables	
Tech	The value one is assigned if the 4-Digit SIC code of the issuer is included in the index of SIC codes of technology and internet stocks in appendix 1. In all other cases, the dummy takes on the value of zero.
Venture Capital (VC) Backing	The value one is assigned when the issuer of the IPO was backed by a venture capitalist at the time of the offering. In all other cases, the dummy takes on the value of zero.
Underwriter Prestige	The value one is assigned if (at least one of) the lead underwriter(s) is ranked 8 or higher at the time of the offering. In all other cases, the dummy takes on the value of zero.
Twenty-Tens Dummy	The value one is assigned if the IPO year is between 2010-2017. In all other cases, the dummy takes on the value of zero.
Control Variable	
Lagged Nasdaq	The 15-day average Nasdaq returns prior to the IPO.

4 Methodology

This section will provide an elaboration on the methods used to conduct my research. First, a time-series analysis of underpricing will be provided for the period 1998-2017 to gain deeper insights in the developments of the average annual first-day returns and the IPO volume. Thereafter an annual and subperiod analysis will be conducted for the volume of IPOs, first-day returns, number of underwriters,

and the money left on the table. The dataset will be divided in the following subperiods: pre-internet bubble year (1998), internet bubble (1999-2000), aughts (2001-2009), and twenty-tens (2010-2017). An extensive univariate sorts and several other advanced sorts will be performed to gain deeper insights between the relationship between various potential explanatory variables and underpricing. The aim is to observe expected patterns between explanatory and underpricing based on existing literature, which will serve as a confirmation they should be included in the multivariate regression as explanatory variables.

A multivariate regression analysis will be conducted to estimate the relationship between the independent variables and the level of underpricing. The Ordinary Least Squares (OLS) model will be used, which has the following form in general:

$$Y_i = \alpha_i + \beta_1 X_{1i} + \cdots + \beta_k X_{ki} + \varepsilon_i \quad (2)$$

Where Y_i represents the first-day return "Y" of company "i". This indicates that the dependent variable Y denotes the degree of underpricing for every issuer i of an IPO in the US from 2001-2017. The constant is represented by α, the independent variables by X_1+…+X_k, the coefficients for each independent variable by β_1+…+β_k, and the error term by ε_i. Specifically, two models that differ only slightly have been created, since issue size and market capitalization are assumed to be mutually exclusive. I will elaborate on this in the results section. The first regression model is defined as follows:

$$Firstday\ Return = \propto_0 + \propto_1 Tech + \propto_2 \ln(1 + Comp\ Age) + \propto_3 UW\ Pres + \propto_4 \mathrm{VC} + \propto_5 Lagged\ Nasdaq + \propto_6 Neg\ Price\ Rev + \propto_7 Pos\ Price\ Rev + \propto_8 Twentytens + \propto_9 \ln(Issue\ Size) + \varepsilon_i \quad (3)$$

Regression model 2 is formulated as follows:

$$Firstday\ Return = \propto_0 + \propto_1 Tech + \propto_2 \ln(1 + Comp\ Age) + \propto_3 UW\ Pres + \propto_4 \mathrm{VC} + \propto_5 Lagged\ Nasdaq + \propto_6 Neg\ Price\ Rev + \propto_7 Pos\ Price\ Rev + \propto_8 Twentytens + \propto_9 \ln(Mkt\ Cap) + \varepsilon_i \quad (4)$$

5 Results

This chapter presents the results of my research. In the first section, I will conduct a time-series analysis of the first-day returns and several key variables over time. The next section will present the univariate sorts in order to exhibit potential patterns between key variables and underpricing. The last section provides the multivariate regression.

5.1 Time-Series Analysis

In this section, the number of IPOs as well as the first-day returns will be analyzed by each year and by the previously mentioned subperiods. Figure 1 plots the annual volume and average first-day return on the IPOs from January 1998 till June 2017.

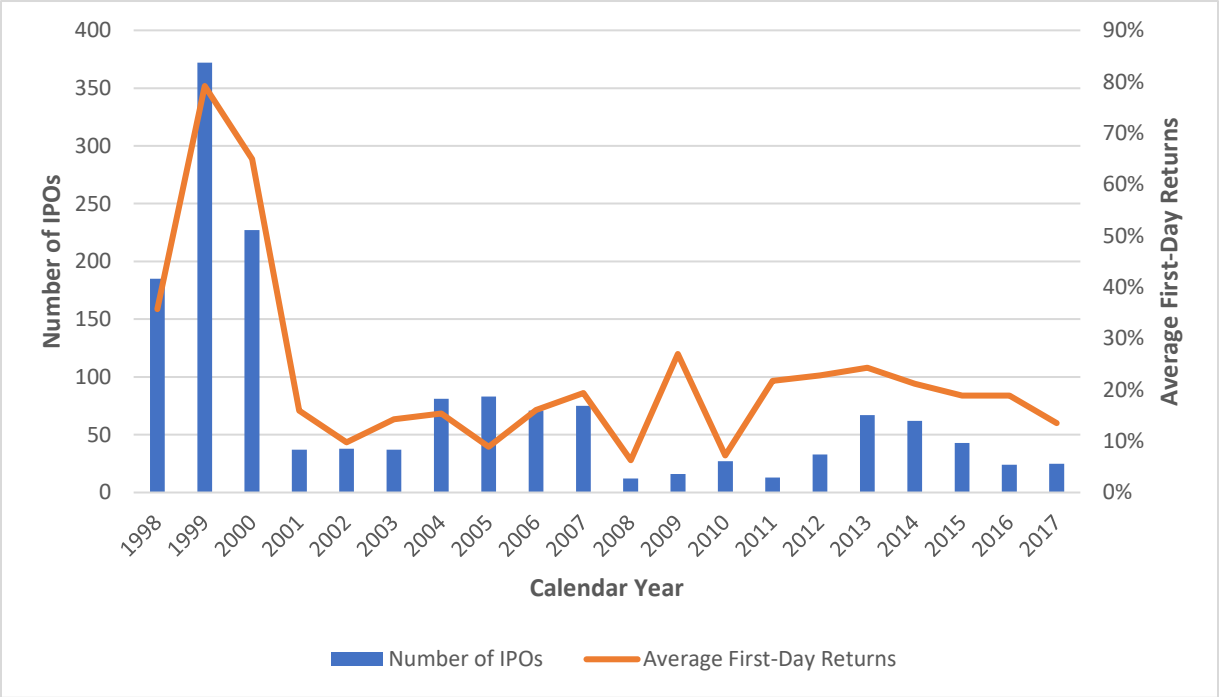

Figure 1: Annual volume of IPOs and average first-day returns.

In this figure, we can clearly observe there was a drastic increase in the annual volume and first-day returns during the internet bubble. In 1998, the year before the internet bubble, the average first-day return was slightly over 35% and the volume of IPOs was round 180. Thereafter the annual volume and average first-day returns of IPOs peaked during the bubble in 1999 to approximately 370 IPOs and 79% before both dropping dramatically after the internet bubble burst in May 2000. The average first-day return acutely dropped after the burst to slightly over 15% in the 2001 before reaching its partial low of 9.77% in 2002. Hereafter, the average underpricing fluctuates between 10% and 20% before dropping to 6% in 2008, which is undoubtedly connected to the global financial crisis. Thereafter, the first day returns gradually start to increase from 2010 till the partial peak in 2013. The number of IPOs also gradually increase from 2011 till they partially peak at 2013 as well. Analysis of the figure shows that the annual number of IPOs tends to move together with the average annual first-day returns.

Table 4 in the appendix provides the annual mean and median for the first-day returns, number of underwriters, money left on the table, issue size, market capitalization, sales, and the number of IPOs. The amount of money left on the table represents the profits that have been made by investors on the first trading day, which is computed as the number of shares offered in all markets multiplied by the difference between the first-day closing price and the offer price.

$$Money\ Left\ On\ The\ Table = Global\ Amount\ of\ Shares\ Offered \times (Firstday\ Closing\ Price - Offer\ Price) \quad (5)$$

The issue size represents the global amount of shares offered multiplied by the offer price:

$$Issue\ Size = Global\ Amount\ of\ Shares\ Offered \times Offer\ Price \tag{6}$$

The market capitalization is calculated as the global amount of shares offered multiplied by the first-day closing price:

$$Market\ Capitalization = Global\ Amount\ of\ Shares\ Offered \times Firstday\ Closing\ Price \tag{7}$$

Inspection of table 4 shows there is an increasing trend noticeable in the average and median number of underwriters at the yearly and subperiods section. The means and median for the money left on the table do not exhibit a trend as clear as the number of underwriters throughout the years. However, it is noteworthy that the mean and median exhibit the same cyclicality as the number of IPOs and first-day average returns, except for 2017. For instance, money left on the table exhibits an exact same jump during the internet bubble as the number of IPOs and average underpricing. For approximately every year the mean is higher than the median for the given variables, which indicates the distribution of those variables is clearly skewed to the right. In 1998 a median issue size of 59.3 million was less than twice the annual sales of 38.3 million. During the internet bubble, the median issue size increased to 69.3 million while the median sales dropped to 23.4 million, resulting in a market-to-sales ratio of 2.96. Using the median market capitalization of 109 million and the median sales of 23.4 million the market-to-sales ratio rises even higher to 4.66 approximately. This immediate jump in market-to-sales ratios imply that valuation uncertainty played a role in the increase in underpricing during the internet bubble. However, the market-to-sales ratio dropped to 0.64 during the aughts (2001-2009) mainly because the median sales jumped to 175.5 million this period. During the twenty-tens the market-to-sales ratio rose to 1.17 approximately, because the median sales dropped slightly. However, this does confirm findings that the occurrence of the technology bubble differs from the internet bubble of 1999-2000, because tech companies are now actually making profits that justify the high valuations in contrast to the internet bubble.

5.2 Univariate Sorts

This section aims to gain deeper insights and observe certain patterns between several key variables and underpricing. Could the changing characteristics of IPOs explain the variation in underpricing over time? In table 5 in the appendix, the average first-day returns on IPOs are presented by each subperiod after several sorts: non-tech vs. tech, young vs. old, low vs. high underwriter prestige, non-venture capital (VC) vs. VC backed, price not revised up vs. price revised up, small vs. large issue size, low vs. high market capitalization, low vs. high sales, and including secondary shares vs. pure primary offering. The industry classification of companies has been conducted based on the index of SIC codes from

Loughran and Ritter (2002a), which is explained in more detail in appendix 1. Company age is computed by subtracting the firm's founding year from the firm's IPO year:

$$Age = Founding\ Year - IPO\ Year \tag{8}$$

Young firms have a company age of 7 years or less and old firms are older than 7 years. The underwriter prestige has been determined by using the index from Loughran and Ritter (2002a), which is explained in more detail in appendix 2. They made some adjustments to the original ranking indexes from Carter and Manaster (1990) and Carter, Dark, and Sing (1998). The company was taken public by a prestigious underwriter if at least one of the underwriters had a ranking of 8.0 or higher at the time of the IPO.

Inspection of table 5 provides some valuable insights in several cross-sectional patterns. The average first-day return is higher for technology stocks and young companies at every subperiod for instance. However, the difference between underpricing the industry and company age sort dropped from approximately 40% and 50% during the internet bubble to around 5% and 3% in the aughts and the twenty-tens respectively. Based on the existing literature and these patters a tech dummy and company age will be included in the multivariate regression. IPOs led by prestigious underwriters and backed by venture capitalists experience more underpricing at every subperiod as well. After the dramatic decrease due to the internet bubble burst the difference in average first-day returns even got stronger from the aughts to the twenty-tens. Therefore, both the prestigious underwriter dummy and the VC backing dummy are included in the regression models. With the highest average underpricing in every subperiod, except 1998, price revision appears to exhibit one of the strongest patterns to underpricing. The difference between IPOs where the price has been revised up and not revised up is substantial at every subperiod and the highest average underpricing of 127.37% has been observed during the internet bubble. Obviously, negative and positive offer price revision will be included in the multivariate regression. Issue size does not exhibit strong patterns related to underpricing except during the internet bubble. The difference in average underpricing between small and large issue sizes are neglectable. Market capitalization seems to have a strong relationship with underpricing indicated by the high differences in every subperiod. Companies with a high market capitalization even experience the greatest amount of average underpricing during the pre-bubble year (1998). Based on existing literature and the mutually exclusiveness both variables will be included in separate regression models. The 12-month trailing sales prior to the offering exhibits no clear relationship with the average underpricing. During the pre-bubble year and the internet bubble firms with low sales are more heavily underpriced, but the pattern reverses/vanquishes during the aughts. Thereafter, the pattern switches again during the twenty-tens, so sales are not included in the

regression analysis. Lastly, source of shares offered does not provide a clear relation as well. During the pre-bubble and internet bubble pure primary IPOs experience more underpricing, but this pattern reverses for the aughts and twenty-tens period. Based on existing literature and these finding sales and source of shares offered are not included in the regression. In the next section, several patterns will be discussed in more detail.

5.2.1 Sales

Issuing firms have been categorized based on their 12 months trailing sales before the offering. In figure 2 below the average first-day returns are calculated categorized by sales and subperiods. Analysis of the average first-day returns within each subperiod exhibit decrease in underpricing the higher the sales during the pre-bubble and internet bubble years, except for the $200 million & above sales category. However, the aughts and twenty-tens subperiod do not exhibit clear observable patterns.

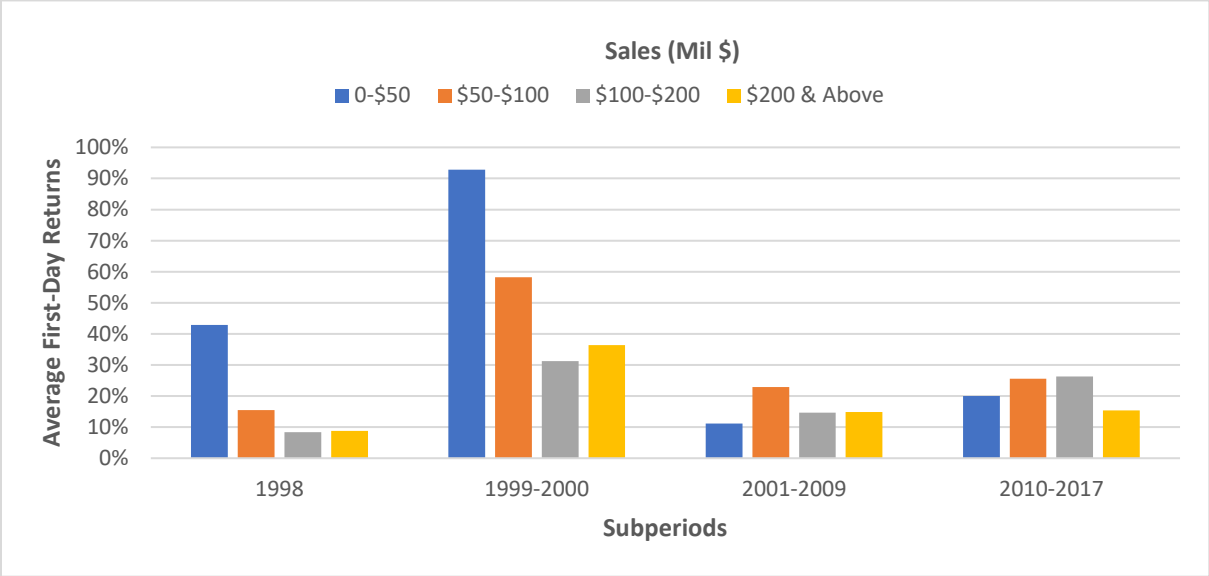

Figure 2: Average first-day returns categorized by sales and subperiods. Sales were missing for 770 firms.

5.2.2 Technology and Internet-related Stocks

In this section, a more detailed analysis will be conducted based on industry classification. Table 3 provides the average first-day returns, percentage of firm sold, and the median market-to-sales ratio categorized by industry. Technology and internet companies are classified according to the index in appendix 1. Inspection of the table confirms the previously observed pattern that tech IPOs are more heavily underpriced than non-tech for every subperiod. The percentage of tech firms increased drastically during the internet bubble before the burst and increased slightly again from the aughts to the twenty-tens. The average first-day returns increased from approximately 22% during the pre-bubble year to 46.50% during the internet bubble, so the increase in average underpricing during the

internet bubble is not entirely attributable to the increased proportion of tech IPOs. However, it is noteworthy that the percentage of tech IPOs tends to move together with the mean first-day returns for each subperiod.

The percentage of firm sold is calculated by dividing the global amount of shares offered by the number of shares outstanding after the offering:

$$Percentage\ of\ firm\ sold = \frac{Global\ amount\ of\ shares\ offered}{Number\ of\ shares\ outstanding\ after\ the\ offering} \quad (9)$$

The average percentage of firm sold is higher for non-tech firms than tech firms in all subperiods, which imply that tech firms offer a smaller proportion of the company. However, holding industry constant the mean percentage of firm sold does not exhibit a clear pattern with underpricing over time. A slight decreasing trend is noticeable when the aughts is disregarded, but based on existing literature and this finding it is not included in the regression analysis.

Table 6: Average first-day returns, percentage of firm sold, and median market-to-sales ratio categorized by industry. Firms were missing values for: 116 for percentage of firm sold and 819 for median market-to-sales ratio.

Segmented By		1998	1999-2000	2001-2009	2010-2017
Number of IPOs	Non-Tech	92	154	258	156
	Tech	93	445	192	138
Percentage Tech		50.27%	74.29%	42.67%	46.94%
Mean First-Day Returns	Non-Tech	22.04%	46.50%	12.31%	16.92%
	Tech	49.25%	83.22%	17.70%	22.70%
Mean Percentage of Firm sold	Non-Tech	50.58%	27.82%	34.80%	26.08%
	Tech	30.60%	22.60%	26.34%	20.31%
Median Market Value/Median Sales Ratio	Non-Tech	1.9	6.3	1.1	1.4
	Tech	9.7	19.0	4.6	5.3

Last, the median market-to-sales is higher for tech companies than non-tech companies in every subperiod, which implies that tech firms are valuated higher on average disregarded their sales. Besides the remarkable high market-to-sales ratio of 19 for tech firms during the internet bubble there is only a slight increasing pattern noticeable from the aughts to the twenty-tens. Therefore, these variables will not be included in the multivariate regression analysis.

5.2.3 Company Age

In this section, I will conduct a more detailed analysis of the relation between company age and underpricing. Figure 3 provides the average first-day return categorized by age for each subperiod.

Analysis of the figure between subperiod shows that the average underpricing was more severe for young firms during the pre-bubble year and during the internet bubble if we look at the age of 0 till 4. However, this pattern is not observed for the aughts or the twenty-tens. These findings are in line with the fact that during the 1980s and 1990s it was less common for, especially prestigious, underwriters to take a young unestablished firm to the public. Moreover, the is a slight decreasing trend with fluctuations noticeable for the pre-bubble and internet bubble subperiods, except the spike at company age 12 for during the internet bubble. The aughts and twenty-tens subperiods do not exhibit a clear relationship between company age and the average first-day returns. Inspection of the figure shows that the fluctuations in underpricing over time is not due to changes in the composition of the age of firms going public. Even more important, it can be observed the relation between are and first-day returns is nonstationary.

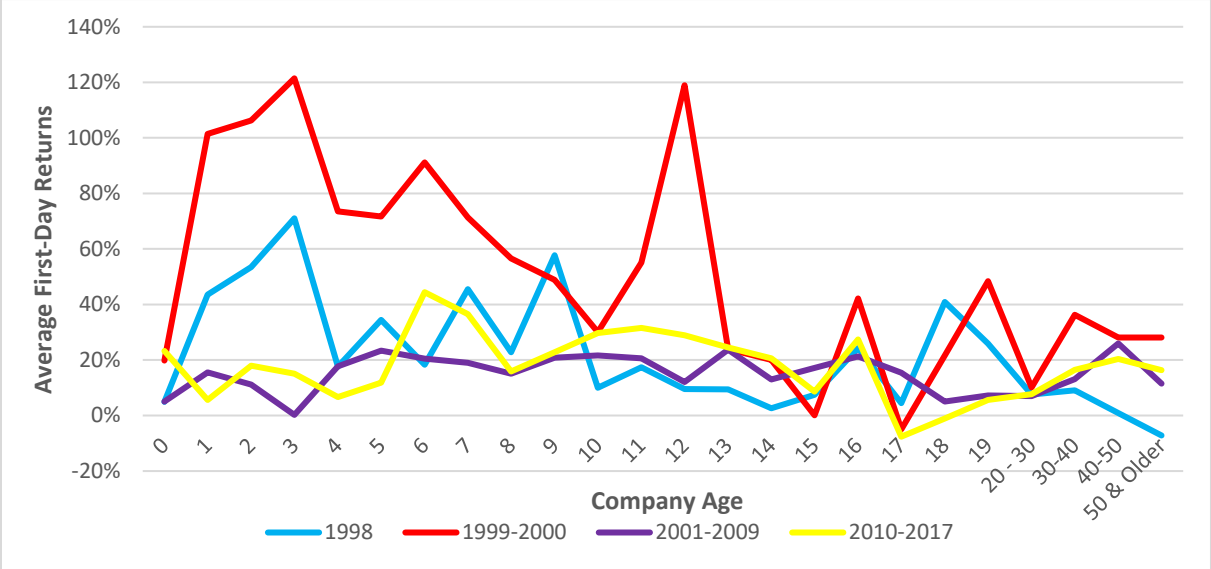

Figure 3: Average first-day returns on IPOs for each subperiod categorized by firm age at the time of the IPO. 480 firms were missing values for age.

5.2.4 Underwriter Prestige

The internet bubble of 1999-2000 has led to analysts at all institutional investors to make very bullish reports on every internet firm regardless of whether there was evidence of these positive foresights with respect to the specific firm. Existing literature has already documented that it can be quite difficult to value internet or technology companies, because of firm specific characteristics relating to these industries. Especially for young firms with growth potential in these specific industries. For example, who could have guessed Snapchat would be such a worldwide successful social media platform before it was famous? How do you evaluate whether a company will be that next “unicorn” company as institutional investor in a world with 1000’s of start-up ideas every day? Besides based on what

characteristics will you evaluate the firm and its growth potential when at that specific moment it was no more than an idea.

This section provides a more detailed analysis of the relationship between the average first-day returns and underwriter prestige before the multivariate regression will be conducted. As been explained in appendix 2 the index from Loughran and Ritter (2002a) will be used to classify the underwriters, which is an updated version of Carter and Manaster's (1990) ranking system for underwriters. This index ranks underwriters from 0 to 9.0 with 0 being the lowest and 9.0 the highest. According to their system underwriters with a Carter and Manaster rank of 8.0 or above are prestigious national underwriters. The underwriters with a rank between 5.0 and 7.9 are quality regional or niche underwriters. Lastly, underwriters with a rank between 0 and 4.9 are linked to penny stocks in general. The majority of underwriters with a rank below 3.0 is accused with market manipulation by the SEC.

Table 7 in the appendix provides the average and median first-day returns, median age, median annual sales 12 months prior to the offering, median EPS 12-month EPS before the offering, percentage of IPOs with a positive price revision, and percentage tech stocks categorized by underwriter prestige. As previously already observed by the mean the median first-day return confirm the positive pattern between high underwriter prestige and underpricing. The median 12-month EPS exhibited no remarkable patterns for the by keeping either the subperiod or underwriter prestige constant. There is also no clear pattern observable for the median company age by keeping subperiod or underwriter prestige constant.

Back in the 1980s it was very uncommon for prestigious to take on the IPO of a young and risky firm, while this became more customary over time. For instance, prestigious underwriter Goldman Sachs was only lead underwriter of 1 tech firm in the 1980, but 15 in the 1990s and even 37 during the internet bubble. The median sales of firms underwritten by prestigious underwriters dropped to $27 million during the internet bubble, which indicates they relaxed their underwriting standards during this bubble. However, the median sales increase to $243 million during the aughts and slightly decreased to $233 million during the twenty-tens, which imply the return of higher standards at prestigious underwriters. Besides the median sales are greater for high prestige underwriters at every subperiod, which confirms that prestigious underwriters do use higher standards than their competition. The percentage of IPOs with a positive offer price revision is higher in every subperiod for prestigious underwriters. It is arguable whether this is caused by the better qualities of high prestige underwriters in creating demand or due to the intentionally underpricing of the file price

range. Finally, there is also no relationship in the percentage of tech stocks observable keeping underwriter prestige or the subperiod constant.

Loughran and Ritter (2002b) argue that the underwriting of IPOs has become more rewarding as valuations increased over time due to bullish analysts. These higher valuations caused the issuing firms to be more receptive to leaving more money on the table, and underwriters stimulated this process by setting up "Friends and family" and "Friends of Frank" allocations. Even a portion of the money left on the table was regained by underwriters through commissions from these buyers, who seek for rents.

5.3 Multivariate regression

The univariate sorts in table 5 to 7 are not entirely independent as tech firms often turn out to be young firms for example. Therefore, a multivariate regression will be conducted with the first-day returns as independent variable to observe the marginal effects of specific variables over the period from 2001 till 2017. In order to perform the multivariate regression analysis 347 IPOs are distracted out of the earlier described sample of 744 IPOs from 2001 till 2017 by excluding IPOs missing values on variables that will be included in the regression. Regression model 1 and 2 only differ slightly, since model 2 contains the natural logarithm of market capitalization instead of the natural logarithm of issue size. These variables are included separately in two different models, because I intend to treat these variables as mutually exclusive to avoid the problem of multicollinearity in a regression. This is caused by the fact that both variables are computed with the same quantitative component global amount of shares offered, which leads to a high level of correlation between both variables.

5.3.1 Regression Model 1

In the first column of table 8 the first-day returns of 347 US IPOs are regressed on a tech stock dummy, the natural logarithm of company age, an underwriter prestige dummy, a Venture Capital (VC) backing dummy, negative offer price revision, positive offer price revision, twenty-tens subperiod dummy, and the natural logarithm of the issue size whereby controlling for the lagged NASDAQ return. Regression model 1 is as follows:

$$Firstday\ Return = \propto_0 + \propto_1 Tech + \propto_2 \ln(1 + Comp\ Age) + \propto_3 UW\ Pres + \propto_4 \mathrm{VC} + \propto_5 Lagged\ Nasdaq + \propto_6 Neg\ Price\ Rev + \propto_7 Pos\ Price\ Rev + \propto_8 Twentytens + \propto_9 \ln(Issue\ Size) + \varepsilon_i \quad (3)$$

Inspection of model 1 in table 5 shows that the VC backing dummy, negative offer price revision, positive offer price revision, and the twenty-tens subperiod dummy are significantly related to the degree of underpricing at a 0.01, 0.01, 0.001, and 0.05 level respectively, which is indicated by the asterisks after the coefficients

*Table 8: Multivariate regression on first-day returns of model 1 and model 2 with their corresponding independent variables, sample size N, and R^2. Under the estimated coefficients of the explanatory variables the t-statistics are provided between parentheses. The asterisks *, **, and *** indicate significance at 5%, 1%, and 0.1% level respectively.*

Explanatory Variable	**Model 1**	**Model 2**
Constant	0.170 (0.70)	-0.775** (-2.82)
Tech Dummy	-0.0479 (-1.86)	-0.0387 (-1.53)
Company Age	-0.000255 (-0.02)	0.00241 (0.21)
Underwriter Prestige	0.0435 (1.33)	-0.0254 (-0.77)
Venture Capital Backing	0.0857** (2.93)	0.107*** (3.74)
Negative Price Revision	0.285** (3.00)	0.177 (1.88)
Positive Price Revision	1.526*** (6.06)	1.445*** (5.92)
Issue Size	-0.00686 (-0.52)	-
Market Capitalization	-	0.0458** (3.05)
Twenty-Tens	0.0602* (2.53)	0.0474* (2.06)
Lagged NASDAQ	0.00143 (0.33)	0.00323 (0.75)
N	347	347
R^2	0.287	0.308

5.3.1.1 Interpretation of Coefficients

The interpretation of the coefficients in this regression model is under the assumption that all other factors stay the same (ceteris paribus). The VC dummy coefficient implies that IPOs backed by VC firms at the time of the IPO experience 8.57 percent more underpricing than non-VC backed IPOs. The negative offer price revision coefficient of 0.285 implies that downward offer price revision of 1 percent point relative to the midpoint of the original file price range will lead to the increase of the first-day returns on the IPO by 0.285% on average. Likewise, does the coefficient of the positive offer price revision of 1.526 imply that the upward offer price revision of 1 percent point relative to the midpoint of the original file price range will lead to the increase of the first-day returns on the IPO by 1.526% on average. Lastly, the coefficient of the twenty-tens subperiod dummy implies that IPOs after 2009 experience higher underpricing by 6.02% on average. In contrast to the patterns observed in the univariate sorts, tech stocks, company age, and underwriter prestige are not significantly related the level of underpricing in this model, which means that these coefficients cannot be properly interpreted in this model. The issue size has no significant relationship to the level of underpricing as well, which indicates this factor cannot be meaningfully interpreted.

5.3.1.2 Overall Fit of The Model

The whole model is significant and the R^2 is 0.2874, which implies that 28.74% of the variation in the first-day returns for is explained by this model. This indicates that, assuming that the sources of information asymmetry are properly covered by the explanatory variables in this model, the majority of the variation in the first-day returns, 71.26%, is explained by other factors than asymmetric information.

5.3.2 Regression Model 2

The second column of table 8 provides the results of regression model 2. As been mentioned before this model only differs slightly compared to model 1, since market capitalization has been incorporated instead of issue size. The formula for regression model 2 is as follows:

$$Firstday\ Return = \propto_0 + \propto_1 Tech + \propto_2 \ln(1 + Comp\ Age) + \propto_3 UW\ Pres + \propto_4 \mathrm{VC} + \propto_5 Lagged\ Nasdaq + \propto_6 Neg\ Price\ Rev + \propto_7 Pos\ Price\ Rev + \propto_8 Twentytens + \propto_9 \ln(Mkt\ Cap) + \varepsilon_i \quad (4)$$

Analysis of regression model 2 in exhibits that the VC dummy, positive offer price revision, market capitalization of the offering, twenty-tens subperiod dummy, and the constant are significantly related to the degree of underpricing at a 0.001, 0.001, 0.01, 0.05, and a 0.05 level.

5.3.2.1 Interpretation of Coefficients

Like before I would like to point out that the interpretation of the coefficients is under the ceteris paribus assumption again. The VC dummy coefficient implies that IPOs backed by VC firms at the time of the IPO experience 10.70% percent more underpricing than non-VC backed IPOs, which is slightly higher than the effect of this variable in model 1. The coefficient of the positive offer price revision of 1.445 implies that the upward offer price revision of 1 percent point relative to the midpoint of the original file price range will lead to the increase of the first-day returns on the IPO by 1.445% on average. This effect is slightly lower than the observed effect for this variable in the previous model. Perhaps its effect was previously overestimated because it included some of the effects of an omitted variable. The coefficient of the natural logarithm of the market capitalization implies that a 1 percent point increase in market capitalization implies a 0.0458% increase in underpricing on average. Lastly, the coefficient of the twenty-tens subperiod dummy implies that IPOs after 2009 experience higher underpricing by 4.74% on average. In contrast to the previously found patterns in the univariate sorts section are the tech dummy, natural logarithm of age, and underwriter prestige dummy insignificant with respect to the level of underpricing, which means their effects on underpricing cannot be meaningfully interpreted. The negative offer price revision is insignificant has become insignificant, perhaps through the significant inclusion of market capitalization.

5.3.2.2 Overall Fit of the Model

The total model significant and the R^2 is 0.308, which implies that 30.80% of the variation in the first-day returns for is explained by this model. This implies that, assuming that the sources of information asymmetry are properly covered by the explanatory variables in this model, the majority of the variation in the first-day returns, 69.20%, is caused by other factors than asymmetric information. In contrast to the previous model is this finding confirmed by the significance of the constant. This means some of the effects of omitted variables are estimated in the significant constant term. Comparing the regression models based on the mutually exclusive variables market capitalization and issue size model 2 including market capitalization is preferred. This decision is based on the significance of the market capitalization variable in contrast to the insignificant variable issue size in combination with the higher R^2 of the preferred model. These observations imply that that the market capitalization is a better contribution to the regression model in explaining the variation in the response variable's variation compared to the issue size.

6 Discussion

Loughran and Ritter (2002a) found that the explanations for the changes in underpricing can vary over time and for each environment. In this research, I aim to test if information asymmetry still is an important explanation for fluctuations in first-day returns in the US from 2001-2017. Based on my results it becomes clear that information still has its share in explaining some of the changes in underpricing. Several proxies for information asymmetry have an explanatory power with respect to the changes in the underpricing.

The results on the variables in the multivariate regression argue that information asymmetry still has an impact on the level of underpricing after the internet bubble. Analysis of the regression shows that venture capital backing, positive price revision, market capitalization, and the twenty-tens subperiod dummy have a significant impact on the degree of underpricing. Therefore, these results indicate that information asymmetry affects the level of underpricing assuming information asymmetry is properly represented by the chosen proxies. However, the tech industry, company age, underwriter prestige, negative offer price revision, and the issue size appear to have no effect of the level of underpricing following from the multivariate regression analysis. Therefore, not all proxies for information asymmetry seem to be a valid reason for changes in the level of underpricing for this more recent period. This could be an indication that through developments over time not every proxy is as important in explaining these changes in underpricing as they were during the internet bubble.

The positive significant relationship between the VC backing and the degree of underpricing in both regression models indicates that VC backing is an important factor in explaining underpricing nowadays as a proxy for information asymmetry. Therefore hypothesis 3, which assumes this positive relationship between VC backing and underpricing, is accepted. Interpretation of this relation is that IPOs backed by venture capitalists at the time of the IPO experience more underpricing of average. This is line with the findings of previous researchers in existing literature (Loughran & McDonald, 2013). There is also a positive significant relationship between positive price revision and the level of underpricing, so this is also an important factor in explaining underpricing today. Indicating that IPOs whose offer price has been revised upwards relative to the midpoint of the official file price range experience substantially more underpricing. This relationship was already expected by the strong observed pattern at the univariate sorts and therefore hypothesis 4 is accepted. This relationship is confirmed by previous studies (Loughran & Ritter, 2002a). Market capitalization is also positively and significantly related to the level of underpricing. Indicating that this variable as proxy for information asymmetry is also an important factor in explaining underpricing these days. IPOs with a high market capitalization will be more heavily underpriced on average, so hypothesis 6 is accepted. Firms with high market capitalization are often linked to high quality firms, which are able to carry the costs of underpricing. This corresponds to the findings that high multiples are a signal to inform the investor about the quality of a firm (Welch, 1989). Lastly, the positive significant relationship between the twenty-tens subperiod and the level of underpricing imply that the subperiod dummy also explains some of variation in underpricing, although this is not a proxy for information asymmetry. Therefore, hypothesis 7, which assumes the level of underpricing to be related to the twenty-tens subperiod, is accepted. This is in line with Loughran and Ritter's (2002a) view that explanations for changes in underpricing vary of time.

However, no evidence was found for company age to be related to underpricing, which means that information asymmetry induced by company age does not contribute in explaining changes in underpricing. Therefore, hypothesis 1 could not be accepted. This is in contrast with previous findings where there is a significant negative relationship is observed between age and the level of underpricing (Loughran & Ritter, 2002a). The results of the regression did not provide any evidence for a relationship between underwriter prestige and the level of underpricing, since the coefficient for the underwriter prestige dummy was not significant. Therefore, underwriter prestige as proxy for information asymmetry has no explanatory power with respect to the variation in underpricing and hypothesis 2 cannot be accepted. This is not in line with findings from existing literature (Beatty & Ritter, 1986). According to the regression results the IPO's issue size is not related to the level of underpricing as well, since the coefficient is not significant. Therefore hypothesis 5 could not be accepted. Although,

not hypothesized I would like to point out that tech stocks are not related to underpricing. This appears somewhat counterintuitive since the univariate sorts clearly showed higher underpricing for tech stocks in all subperiods. Besides other have found a significant positive relationship between tech stocks and the degree of underpricing (Loughran & Ritter, 2002a).

By analyzing preferred model 2 based on information asymmetry between the issuers, underwriters, and investors about half of the proxies included in this model are related to underpricing recent years. Analysis of the regression result show that information asymmetry causes approximately 30% of the variation of underpricing for the period of 2000-2017. Indicating that information asymmetry's role in explaining the level of underpricing at IPOs is present, but modest these days. Therefore, it can be stated that information asymmetry does not take an as dominant role in explaining the level of underpricing as it did during the internet bubble.

7 Conclusion

This paper investigates the puzzle of short-term underpricing of IPOs and explanations for the level of underpricing. In line with Loughran and Ritter's (2002a) findings that explanations for the level of underpricing vary with environmental factors and over time, this paper aims to examine the role of information asymmetry on the underpricing of IPOs these days. Therefore, the research question has been formulated as follows:

What is the effect of information asymmetry on underpricing at IPOs?

Even though a broad and extensive amount of existing literature about the underpricing anomaly and its potential explanations is present already, there is still a lot of discussion regarding this matter. Theories regarding information asymmetry between the various involved parties, like issuers, underwriters, and investors play a dominant role in the existing literature. Therefore, this study examines this explanation in more detail for today's IPO market.

The first-day returns for the US IPO market are analysed from 2001-2017 by using data on 1528 US IPOs. For the whole sample of 1998-2017 an average level of underpricing of approximately 41% is observed. However, the average amount of underpricing is biased upwards since the IPOs from 1998 and during the internet bubble are overrepresented in the sample. Therefore, if we exclude this period an average level of underpricing of 16.59% is observed for 2001-2017, which is more useful than the average underpricing including this period. The period of 1998-2000 is mainly included in the sample to gain deeper insights in developments in the cross-sectional patterns through the univariate sorts. The analysis of the average level of underpricing in subperiods exhibit that the average level of

underpricing dropped from its peak of 73.78% during the internet bubble to 14.61% in the aughts. Thereafter the average level of underpricing rose to 19.63% during the twenty-tens subperiod.

To explain the variation in the average level of underpricing from 2001-2017 various proxies of information asymmetry have been used to test the effect of information asymmetry on underpricing. These proxies are based on the observed patterns in the univariate sorts section and existing literature on the underpricing anomaly. The 2 regression models imply that information asymmetry still has explanatory power with respect to the variation in underpricing, but it is modest these days compared to the internet bubble period. The results of the regression show that VC backing at the time of the offering, positive offer price revision, and market capitalization have a significant positive relationship to the level of underpricing, which are all proxies for information asymmetry. The twenty-tens subperiod dummy also shows a positive significant relationship to the degree of underpricing, although not being related to information asymmetry. Lastly, the regression results exhibited no evidence for tech stocks, company age, underwriter prestige, negative offer price revision, and issue size to be related to the level of underpricing.

The analysis of the level of underpricing in this research present evidence that information asymmetry has modest role in explaining the variation of underpricing from 2001-2017, assuming information asymmetry was correctly represented by the chosen proxies. The regression results show that with an R^2 of 0.308 in model 2 that information asymmetry can explain about 30% of the variation in underpricing for this period.

8 Limitations and Recommendations

Although I believe the findings in this paper to be a useful contribution to the existing literature on the IPO short-term underpricing anomaly I would like to point out several limitations regarding this study. First, I must acknowledge there were some limitations regarding the availability and in some cases reliability of the data, especially financial data on the issuers prior to going public. This is caused by some complications related to the financial database ThomsonOne. Even though this source provides financial data from annual reports and data on acquisitions, mergers, and IPOs, the data is mainly focussed on publicly listed companies. Therefore, in some cases there was relatively little data available like financial variables, used as proxies for information asymmetry, from the issuers prior to going public. After a personal appointment with the data team of the Erasmus University regarding this matter the options were discussed and it became clear there were no better data sources available, so it was concluded to go with the data available. However, this lead to a smaller sample size at the multivariate regression analysis and the exclusion of potential proxies for information

asymmetry, like share overhang for instance. When analysing existing literature, I noticed that usually an experienced team is involved in gathering missing data from alternative sources and the correction of unlikely or erroneous values. However, due to lack in time, resources, and expertise it was not feasible to address complications of this matter. From previous studies I am aware of data corrections to founding dates gathered through financial database ThomsonOne, so complications due to this matter could have led to not finding a significant relationship between company age and the level of underpricing. Therefore, future research could provide an opportunity to address the problem of missing values and correction of unlikely or erroneous values. This could be solved by having more time and experience in acquiring data on the missing values through alternative sources like the prospectus of an IPO for instance. However, one can imagine this to be time consuming for large samples.

Appendices

Appendix 1: Classification of Internet and Technology Companies

To identify internet and technology firms an index of 4-digit Standard Industrial Classification (SIC) codes has been used from Loughran and Ritter (2002a). They classify internet and technology companies based on the following SIC codes: 3571, 3572, 3575, 3577, 3578, 3661, 3663, 3669, 3674, 3812, 3823, 3825, 3826, 3827, 3829, 3841, 3845, 4812, 4813, 4899, 7370, 7371, 7372, 7373, 7374, 7375, 7378, and 7379.

In the file "IPOs 2016 Tech Stock IPOs" from professor Jay R. Ritter an update is provided on the index of SIC of internet and technology stocks. The SIC codes 3559, 3576, and 7389 should be added to the list. The link to professor Jay R. Ritter's personal website is: https://site.warrington.ufl.edu/ritter/ipo-data/

Appendix 2: Classification of Prestigious Underwriters

To identify prestigious underwriters the underwriter rankings index from Loughran and Ritter (2002a) has been used. The document "IPO Underwriter Reputation Rankings (1980-2015)" can be found on professor Jay R. Ritter's personal website as well: https://site.warrington.ufl.edu/ritter/ipo-data/
They have made several adjustments to the original ranking indexes from Carter and Manaster (1990) and Carter, Dark, and Singh (1998), which are indicated by the decimal 0.1 so adjustments are easily recognizable since these decimals were not used at the original indexes. Prestigious underwriters are identified as underwriters with a ranking of 8.0 of higher during the year of the IPO.

Table 3: An elaboration on the definition and measurement of independent variables used at the univariate sorts.

Variable	Interpretation and Measurement
Offer Price	The price per share in US $ at which the stock is offered to the public.
First-Day Closing Price	The closing price of the stock in US $ on the first trading day.
Number of Underwriters	The number of lead underwriters, co-lead underwriters, and co-managers of the IPO.
Money Left on the Table	This variable represents the lower amount of proceeds obtained by the issuer through the offer price setting of the underwriter at the IPO. Computed as the number of shares offered in all markets multiplied by the difference between the first-day closing price and the offer price.
Proceeds	Total proceeds in all markets of the IPO in millions of US $.
Pure Primary Dummy	The value of one is assigned if the IPO only includes primary shares. If the IPO also includes secondary shares it takes on the value zero.

Table 4: Annual and subperiod analysis of the number of IPOs, first-day return, number of underwriters, and money left on the table, issue size, market cap, and sales.

	Number of IPOs	Average First-Day Return		Number of Underwriters		Money Left on the Table (Mil $)		Issue Size (Mil $)		Market Capitalization (Mil $)		Sales (Mil $)	
Year		Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
1998	185	35.72%	13.04%	3.04	3	$ 23.7	$ 6.5	$ 107.1	$ 45.5	$ 130.8	$ 59.3	$ 156.3	$ 38.3
1999	372	79.16%	46.74%	3.58	3	$ 83.2	$ 30.0	$ 126.6	$ 64.0	$ 209.8	$ 105.7	$ 701.5	$ 24.8
2000	227	64.96%	34.70%	3.63	3	$ 87.0	$ 26.0	$ 123.3	$ 76.0	$ 210.3	$ 113.4	$ 104.7	$ 21.2
2001	37	15.94%	16.29%	3.92	3	$ 21.6	$ 14.2	$ 515.6	$ 123.5	$ 537.1	$ 130.6	$ 478.3	$ 31.7
2002	38	9.77%	7.45%	4.84	4	$ 15.5	$ 7.2	$ 157.5	$ 90.0	$ 173.0	$ 107.3	$ 854.9	$ 378.1
2003	37	14.26%	10.29%	4.00	4	$ 17.6	$ 13.1	$ 164.2	$ 118.8	$ 181.8	$ 131.3	$ 412.5	$ 196.5
2004	81	15.38%	11.18%	4.69	4	$ 30.4	$ 9.2	$ 174.3	$ 93.0	$ 204.7	$ 108.9	$ 416.4	$ 119.4
2005	83	8.93%	4.62%	4.89	4	$ 14.5	$ 5.2	$ 204.2	$ 121.5	$ 218.8	$ 131.3	$ 715.1	$ 219.4
2006	71	16.04%	11.54%	4.89	4	$ 28.1	$ 16.7	$ 199.9	$ 127.5	$ 228.0	$ 151.0	$ 640.7	$ 213.9
2007	75	19.36%	13.77%	5.21	5	$ 36.8	$ 14.5	$ 178.8	$ 100.1	$ 215.5	$ 132.6	$ 384.0	$ 97.8
2008	12	6.29%	-3.01%	5.50	6	$ 51.6	$ -1.5	$ 246.2	$ 177.8	$ 297.8	$ 152.1	$ 153.3	$ 186.3
2009	16	26.99%	17.29%	6.88	6	$ 91.2	$ 36.3	$ 381.7	$ 146.6	$ 472.9	$ 163.8	$ 1,982.2	$ 863.1
2010	27	7.21%	0.53%	5.63	5	$ 5.6	$ 0.9	$ 119.9	$ 82.3	$ 125.5	$ 95.6	$ 466.3	$ 113.7
2011	13	21.73%	21.00%	7.23	6	$ 45.0	$ 22.5	$ 289.7	$ 96.5	$ 334.7	$ 123.8	$ 353.2	$ 104.8
2012	33	22.80%	18.00%	7.27	6	$ 38.3	$ 18.1	$ 654.4	$ 107.1	$ 692.7	$ 131.3	$ 891.7	$ 203.3
2013	67	24.27%	14.58%	7.42	6	$ 66.9	$ 29.6	$ 281.6	$ 177.5	$ 348.5	$ 221.9	$ 1,055.0	$ 207.4
2014	62	21.19%	10.83%	6.85	6	$ 33.9	$ 15.6	$ 192.2	$ 104.3	$ 226.1	$ 142.2	$ 745.4	$ 147.3
2015	43	18.87%	15.45%	7.00	7	$ 48.4	$ 12.9	$ 232.9	$ 156.8	$ 281.2	$ 196.5	$ 1,093.8	$ 269.9
2016	24	18.88%	4.96%	7.08	7	$ 26.1	$ 5.6	$ 183.2	$ 118.6	$ 209.3	$ 137.9	$ 584.3	$ 171.0
2017	25	13.53%	13.57%	9.08	9	$ 79.8	$ 12.5	$ 380.9	$ 225.0	$ 460.6	$ 282.8	$ 846.0	$ 404.5
1998	185	35.72%	13.04%	3.04	3	$ 23.7	$ 6.5	$ 107.1	$ 59.3	$ 130.8	$ 59.3	$ 156.3	$ 38.3
1999 - 2000	599	73.78%	40.00%	3.60	3	$ 84.6	$ 27.9	$ 125.4	$ 69.3	$ 210.0	$ 109.0	$ 454.4	$ 23.4
2001 - 2009	450	14.61%	10.00%	4.84	4	$ 27.9	$ 10.6	$ 219.7	$ 112.8	$ 247.6	$ 133.3	$ 601.1	$ 175.5
2010 - 2017	294	19.63%	13.54%	7.16	6	$ 45.2	$ 15.3	$ 283.4	$ 122.0	$ 328.6	$ 146.7	$ 853.9	$ 104.5
Total	1528	41.33%	16.73%	4.58	4	$ 52.9	$ 15.1	$ 181.3	$ 83.3	$ 234.3	$ 116.3	$ 602.5	$ 104.5

Table 5: Average first-day returns on IPOs categorized by industry, age, underwriter prestige, venture capital backing, price revision, issue size, market capitalization, sales, and source of shares offered. Firms were missing values for the following variables: 479 for age, 770 for sales, and 8 for price revision.

Segmented By		1998		1999-2000		2001-2009		2010-2017	
		Return	**N**	**Return**	**N**	**Return**	**N**	**Return**	**N**
Industry	Non-Tech	22.04%	92	46.50%	154	12.31%	258	16.92%	156
	Tech	49.25%	93	83.22%	445	17.70%	192	22.70%	138
Company Age	Young (0-7 Years Old)	43.01%	68	92.39%	225	17.58%	116	22.03%	109
	Old (8 Years and Older)	15.47%	54	39.76%	102	14.81%	233	19.07%	142
Underwriter Prestige	Low	15.39%	67	37.43%	147	10.10%	85	10.18%	38
	High	47.26%	118	85.60%	452	15.66%	365	21.04%	256
Venture Capital (VC) Backing	Non-VC Backed	33.53%	124	38.88%	199	9.64%	276	13.77%	172
	VC Backed	40.71%	61	91.14%	400	22.49%	174	27.90%	122
Price Revision	Not Revised Up	32.84%	153	43.23%	382	8.81%	340	11.99%	224
	Revised Up	51.54%	30	127.37%	215	32.55%	110	46.11%	66
Issue Size	Small	36.15%	92	**50.73%**	297	**12.91%**	220	19.29%	143
	Large	35.29%	93	**96.45%**	302	**16.23%**	230	19.96%	151
Market Capitalization	Low	10.11%	92	23.39%	299	9.49%	222	13.65%	144
	High	61.06%	93	124.00%	300	19.59%	228	25.38%	150
Sales	Low	49.10%	40	**95.21%**	92	**14.44%**	118	**24.27%**	125
	High	9.68%	40	**60.44%**	94	**15.60%**	121	**16.65%**	128
Source of Shares Offered	Including Secondary shares	33.43%	71	**46.19%**	89	**16.89%**	219	22.11%	122
	Exclusively Sold by Firm	37.14%	114	**78.60%**	510	**12.44%**	231	17.88%	172
Total		35.72%	185	73.78%	599	14.61%	450	19.63%	294

Table 7: Average and median first-day returns, median age, median annual sales 12 months prior the offering, median 12-month EPS before the offering, percentage of IPOs with an upward price revision, and percentage tech categorized by underwriter prestige for every subperiod. Firms were missing values for the following variables: 479 for age, 778 for sales, 819 for EPS, and 8 for price revision.

Segmented By		1998		1999-2000		2001-2009		2010-2017	
		Item	N	Item	N	Item	N	Item	N
Mean First-Day Returns	Low Prestige	15.39%	67	37.43%	147	10.10%	85	10.18%	38
	High Prestige	47.26%	118	85.60%	452	15.66%	365	21.04%	256
Median First-Day Returns	Low Prestige	10.00%	67	18.80%	147	4.00%	85	0.82%	38
	High Prestige	15.63%	118	50.33%	452	11.39%	365	14.43%	256
Median Company Age	Low Prestige	7	44	6	73	9	65	12	31
	High Prestige	6	78	5	254	11	268	8	220
Median Trailing Sales (Mill $)	Low Prestige	$ 28	33	$ 11	46	$ 43	41	51	30
	High Prestige	$ 42	47	$ 27	140	$ 243	190	$ 233	223
Median Trailing 12-month EPS	Low Prestige	$ -0.02	28	$ -0.45	41	$ -0.11	44	$ -0.30	30
	High Prestige	$ 0.01	39	$ -0.53	127	$ 0.17	182	$ -0.20	218
Percentage Positive Price Revision	Low Prestige	11.94%	67	23.13%	147	15.29%	85	2.63%	38
	High Prestige	11.97%	116	40.22%	450	26.58%	365	24.53%	65
Percentage Tech	Low Prestige	40.30%	67	73.47%	147	30.59%	85	44.74%	38
	High Prestige	55.93%	118	74.56%	452	45.48%	365	47.27%	256
Total		35.72%	185	73.78%	599	14.61%	450	19.63%	294

References

Aggarwal, R. K., Krigman, L., & Womack, K. L. (2002). Strategic IPO underpricing, information momentum, and lockup expiration selling. *Journal of Financial Economics*, *66*(1), 105-137.

Baron, D. P. (1982). A model of the demand for investment banking advising and distribution services for new issues. *The Journal of Finance*, *37*(4), 955-976.

Beatty, R. P., & Ritter, J. R. (1986). Investment banking, reputation, and the underpricing of initial public offerings. *Journal of Financial Economics*, *15*(1-2), 213-232.

Berk, J., & DeMarzo, P. (2014). *Corporate Finance.* Harlow: Pearson.

Boubaker, A., & Mezhoud, M. (2011). Impact of managerial ownership on operational performance of IPO firms: French context. *International Journal of Management Science and Engineering Management*, *6*(3), 191-197.

Bundoo, S. K. (2007). An analysis of IPOs underpricing in Mauritius. *African Journal of Accounting, Economics, Finance and Banking Research*, 1(1), 1-12.

Carter, R., & Manaster, S. (1990). Initial public offerings and underwriter reputation. *the Journal of Finance*, *45*(4), 1045-1067.

Carter, R. B., Dark, F. H., & Singh, A. K. (1998). Underwriter reputation, initial returns, and the long-run performance of IPO stocks. *The Journal of Finance*, *53*(1), 285-311.

Chan, K., Wang, J., & Wei, K. J. (2004). Underpricing and long-term performance of IPOs in China. *Journal of Corporate Finance*, *10*(3), 409-430.

Grinblatt, M., & Hwang, C. Y. (1989). Signalling and the pricing of new issues. *The Journal of Finance*, *44*(2), 393-420.

Ibbotson, R. G. (1975). Price performance of common stock new issues. *Journal of Financial Economics*, *2*(3), 235-272.

Ibbotson, R. G., & Jaffe, J. F. (1975). “Hot issue” markets. *The Journal of Finance*, *30*(4), 1027-1042.

Ibbotson, R. G., Sindelar, J. L., & Ritter, J. R. (1994). The market's problems with the pricing of initial public offerings. *Journal of Applied Corporate Finance*, *7*(1), 66-74.

Jagannathan, R., & Sherman, A. E. (2006). *Why do IPO auctions fail?* National Bureau of Economic Research, 12151.

Ljungqvist, A. P. (1997). Pricing initial public offerings: Further evidence from Germany. *European Economic Review*, *41*(7), 1309-1320.

Ljungqvist, A. P., Jenkinson, T., & Wilhelm Jr, W. J. (2003). Global integration in primary equity markets: The role of US banks and US investors. *The Review of Financial Studies*, *16*(1), 63-99.

Loughran, T., & Ritter, J. R. (2002a). Why don’t issuers get upset about leaving money on the table in IPOs? *The Review of Financial Studies*, *15*(2), 413-444.

Loughran, T., & Ritter, J. R. (2002b) Why Has IPO Underpricing Changed Over Time? *Financial Management, Vol. 33, No. 3.*

Michaely, R., & Shaw, W. H. (1994). The pricing of initial public offerings: Tests of adverse-selection and signalling theories. *The Review of Financial Studies*, *7*(2), 279-319.

Miller, E. M. (1977). Risk, uncertainty, and divergence of opinion. *The Journal of Finance*, *32*(4), 1151-1168.

Miller, R. E., & Reilly, F. K. (1987). An examination of mispricing, returns, and uncertainty for initial public offerings. *Financial Management*, 33-38.

Ritter, J. R. (1984). The" hot issue" market of 1980. *Journal of Business*, 215-240.

Rock, K. (1986). Why new issues are underpriced. *Journal of Financial Economics*, *15*(1-2), 187-212.

Welch, I. (1989). Seasoned offerings, imitation costs, and the underpricing of initial public offerings. *The Journal of Finance*, *44*(2), 421-449.