



Underpricing of CVC and IVC backed IPOs - Do they differ?

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Table of content

Acknowledgements	I
Abstract	II
Resumo.....	III
List of Abbreviations.....	IV
List of Tables.....	V
1. Introduction.....	1
2. Literature Review.....	3
2.1. General definition and different types of Venture Capital	3
2.2. Definition and reasons for the phenomenon of IPO underpricing.....	4
2.3. The impact of Venture Capital on the IPO underpricing.....	5
3. Methodology and Data.....	8
3.1. Data construction.....	8
3.2. Methodology.....	9
3.2.1. OLS-Regression.....	9
3.2.2. Unadjusted first-day return matching	11
3.2.3. Propensity Score Matching Procedure.....	12
4. Empirical Analysis of IPO underpricing.....	13
4.1. Results	14
5. Robustness Test	26
6. Main results.....	27
7. Limitations and Further Research	28
8. Conclusion	29
9. References.....	30

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Abstract

Title: Underpricing of CVC and IVC backed IPOs - Do they differ?

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This dissertation compares the impact of CVC and IVC backing on the underpricing of IPOs. A dataset was compiled consisting of 76 CVC backed and 536 IVC backed companies based in the United States which went public in the period from 2000 to 2020. The required information was taken from Thomson Reuters and Compustat Capital IQ. OLS regressions, a matching method according to Megginson and Weiss (1991), and a propensity score matching method were used. In addition to the entire period from 2000 to 2020 the periods 2000 to 2009 and 2010 to 2020 were examined. The OLS regressions and the matching method of Megginson and Weiss (1991) showed a significant difference in underpricing between CVC backed and IVC backed IPOs for the period from 2000 to 2009. The underpricing of CVC backed IPOs is significantly lower than the underpricing of IVC backed IPOs for this period. Although the propensity score matching results also showed a lower underpricing of CVC backed IPOs than IVC backed IPOs, these results were not significant. The results of this dissertation thus show that the difference in the influence of CVC and IVC backing on underpricing in an IPO has changed over time. While there was still a significant difference from 2000 to 2009 in two of the three models, this difference is no longer present in the more recent period from 2010 to 2020.

Key Words: Initial Public Offering, Venture Capital, Corporate Venture Capital, Independent Venture Capital, Underpricing

Resumo

Título: Subpreço de OPIs apoiadas por CVC e IVC - São diferentes?

Autor: Dennis Murer

Esta dissertação compara o impacto do apoio do CVC e do IVC na subavaliação dos preços das OPI. Foi compilado um conjunto de dados constituído por 76 empresas apoiadas por CVC e 536 empresas apoiadas por IVC sediadas nos Estados Unidos, que se tornaram públicas no período de 2000 a 2020. A informação necessária foi retirada da Thomson Reuters. Foram utilizadas regressões OLS, um método de correspondência de acordo com Megginson e Weiss (1991), e um método de correspondência de propensão. Para além de todo o período de 2000 a 2020, foram examinados os períodos de 2000 a 2009 e 2010 a 2020. As regressões OLS e o método de correspondência de Megginson/Weiss (1991) mostraram uma diferença significativa na subprecificação entre as OPI apoiadas pelo CVC e as OPI apoiadas pelo IVC para o período de 2000 a 2009. A subpreçabilidade das OPI apoiadas por CVC é significativamente inferior à subpreçabilidade das OPI apoiadas por IVC para este período. Embora a pontuação de propensão correspondente aos resultados também tenha mostrado uma subprecificação inferior das OPI apoiadas em CVC do que as OPI apoiadas em IVC, estes resultados não foram significativos. Os resultados desta dissertação mostram assim que a diferença na influência do apoio de CVC e IVC na subcotação de preços de uma OPI mudou ao longo do tempo. Embora tenha havido ainda uma diferença significativa de 2000 a 2009 em dois dos três modelos, esta diferença já não está presente no período mais recente, de 2010 a 2020.

Palavras-chave: Oferta Pública Inicial, Capital de Risco, Capital de Risco Corporativo, Capital de Risco Independente, Desprecificação

List of Abbreviations

CRSP	Center of Research in Security Prices
CVC	Corporate Venture Capital
EBITDA	Earnings before Interest Taxes Depreciations and Amortizations
IPO	Initial Public Offering
IVC	Independent Venture Capital
SIC	Standard Industrial Classification
VC	Venture Capital
VEIC	Venture Economics Industry Codes
WRDS	Wharton Research Data Services

List of Tables

Table 1. Distribution and characteristics of CVC backed, and IVC backed IPOs/Companies	16
Table 2. Correlation matrix	19
Table 3. OLS Regressions to test the impact of CVC backing on the underpricing of an IPO	20
Table 4. Test for differences in underpricing of CVC-Backed and IVC-Backed IPOs Unadjusted first-day returns for CVC backed and "matched" IVC backed IPOs.	22
Table 5. Test for differences in underpricing of CVC-Backed and IVC-Backed IPOs Probit Model Regressions and Selection bias-adjusted initial return differences.....	24

1. Introduction

The relevance of venture capital (VC) investments has increased significantly in recent years (Megginson W. L., 2004; Cumming and Johan, 2012). VC firms can play an essential role in developing their portfolio companies. In addition to financial support, they also assist in operational improvements (Berger & Udell, 1998). There are two basic types of VC investors: corporate venture capitalist (CVCs) and independent venture capitalist (IVCs) (Gompers & Lerner, 1998). The two types differ fundamentally in structure, interests, and motivation. While IVCs, as limited partnership corporations, invest their investors' money in companies with high growth potential, CVCs are subsidiaries of existing and established companies that invest in companies that primarily offer them long-term strategic added value (Wang & Wan, 2013). Therefore, the motivation of IVCs is primarily high returns for themselves and their investors. In contrast, CVCs pursue the long-term strategic goal of creating technologies from the portfolio companies for the parent company (Gompers & Lerner, 2000).

One of the most popular methods VC firms use to either liquidate their investments in the portfolio company or raise additional money for the further growth of the portfolio company is the initial public offering (IPO) (Black & Gilson, 1998). According to Jay R. Ritter's collected data, from 1998 to 2021, 3,509 IPOs were made by VC-funded companies in the United States. In the process, \$353.685 million was raised. On the first trading day after the official IPO, the value of the 3,509 IPOs totaled \$479,530 million. This corresponds to an absolute first day return difference of \$125,845 million which equals approximately 36.0%. The difference between the IPO offer price and the share price at the end of the first trading day is known as underpricing or “money left on the table” (Ritter & Loughran, 2002; McGough & Smith, 1999; Ritter, 2011). Thus, the underpricing from 1998 to 2021 IPOs of VC-funded companies was around 36.0%, which means that around \$126,000 million was left on the table.

A large number of studies examining VC-backed IPOs have already been conducted. One of the earliest were Megginson and Weiss (1991). To investigate the effect of venture capital financing on underpricing, they compared non-sponsored IPOs with VC backed IPOs from 1983 to 1987 and found that the underpricing of VC backed IPOs was significantly lower than the underpricing of non-sponsored IPOs. The authors anticipated this result because VC firms would be expected to know the exact value of their portfolio companies, leading to a reduction in information asymmetry. They defined this effect as the Certification hypothesis (Megginson & Weiss, 1991). In contrast Gompers (1996) and Lee and Wahal (2004) provided contradicting

findings. The authors also investigated the difference in underpricing between VC backed and non-sponsored IPOs. They found that the underpricing of VC backed IPOs is significantly higher than the underpricing of non-sponsored IPOs. Gompers (1996) and Lee and Wahal (2004) based their results on the grandstanding hypothesis, which states that VCs try to bring their portfolio companies to the stock exchange as quickly as possible in order to improve their reputation and thus to be able to raise new capital for further funds more quickly (Lee & Wahal, 2004). In the existing literature, the difference in underpricing between VC backed and non-sponsored IPOs has been studied by numerous scholars. What has rarely been studied is whether there is a difference between the two main VC types, CVC and IVC, in IPO underpricing. The research question of this study is, therefore:

Is there a difference in the underpricing of CVC backed and IVC backed IPOs? If so, which of the two VCs has lower underpricing?

Only one paper could be identified in which the authors examined the different influences on underpricing of CVC backed, and IVC backed IPOs. Wang and Wan (2013) used OLS regressions and concluded that CVC financing has a negative impact on underpricing, whereas IVC financing has a positive impact on underpricing. However, since the existing data could be a so-called selection bias, as the expression of CVC is not random and furthermore is an endogenous choice, it is necessary to apply models that control for this bias. This was done in the present study.

This paper contributes to increase the paucity of studies investigating the influences of different types of VCs on underpricing. Different Stakeholders as VCs, companies and investors could benefit from the study's findings. CVCs and IVCs planning an IPO can thus better assess to what extent they have to expect underpricing. Furthermore, this paper contributes to show not only how VCs face underpricing in an IPO but also how the different types of VCs (CVC and IVC) differ. However, this paper does not only contribute to the potential VCs but also to the companies and investors involved in the IPO. These two parties also benefit from the results of the paper in that they can better anticipate the expected underpricing of an IPO in which they are involved. This work also guides a contribution on which further research can be built.

This research is structured as follows. It starts with a literature review, which covers the research on the general definition and different types of Venture Capital [2.1], definition and reasons for the phenomenon of IPO underpricing [2.2] and the impact of Venture Capital on the IPO underpricing [2.3]. This section is followed by outlining the hypotheses development

[3]. Afterwards, the data and methodology are presented, separated in the data construction [4.1], methodology [4.2], which includes in OLS regressions [4.2.1], unadjusted first-day return matching [4.2.2] and the propensity score procedure [4.2.3]. Following that, in the Empirical Analysis of IPO underpricing, the results are presented [5.1]. This is followed by the illustration of the main results [6]. Then, limitations and further research are presented [7], ending with the conclusion [7].

2. Literature Review

This section will first discuss the general definition and the different types of VC, followed by a more detailed analysis of the phenomenon of IPO underpricing in the existing literature. Finally, we will discuss the current findings regarding the influence of venture capital on IPO underpricing. Based on these existing findings, the hypotheses to be investigated in this thesis are presented, intended to complement the existing research.

2.1. General definition and different types of Venture Capital

Metrick and Yasuda (2021) divide the description of VC into five primary areas. VC is a type of financial intermediary that manages investors' capital and invests it directly in potential portfolio companies. A VC only invests in private companies, which means that the shares in the portfolio company cannot be traded on a public exchange after the investment has been made. A VC takes an active role in supporting the portfolio companies financially and operationally (Gorman & Sahlman, 1989). In general, the primary goal of the majority of VCs is to maximize the financial return of existing investments through a sale or an initial public offering (Metrick & Yasuda, 2021).

In the literature, most economists in the field of venture capital agree that venture capital can be divided into two main types. On the one hand, Corporate Venture Capitalists in the following work abbreviated with CVCs and on the other hand, Independent Venture Capitalists are abbreviated with IVCs (Maula, Autio, & Murray, 2005). Gompers and Lerner (1998) were one of the first to give such a distinction and a more detailed definition in this field. They describe IVCs as limited partnership corporations with the primary objective of investing their investors' capital in new companies with innovative business ideas and high growth potential. On the other hand, CVCs are subsidiaries of existing and established companies. The different fund and investor structures also lead to different motivations and goals. In the case of IVCs, the

main objective is to increase the financial returns of their portfolio companies to increase their market value and thus generate the highest possible return on an exit.

In comparison, the primary objective of a CVC is to achieve strategic goals rather than financial goals (Chesbrough, 2002). A CVC focuses its investments on supporting companies that then create a variety of innovations to be implemented and used in the parent company's operations (Dushnitsky & Lenox, 2006). The overarching strategic goal of CVCs is to invest primarily in companies that are expected to develop access to new technologies and unique business models (Gompers & Lerner, 2000). Companies from various sectors such as Reuters, UPS, and Microsoft started establishing their own CVCs to invest in attractive start-ups and extract innovations in their own core business (Hellmann, 2002). According to Park & Steensma (2013), CVC backed companies generate a higher output of innovations than comparable IVC backed start-ups. This observation fits the different motivations of the two VC types described above.

2.2. Definition and reasons for the phenomenon of IPO underpricing

IPOs are one of the most popular and relevant ways to raise additional capital for a company's future growth (Wang & Wan, 2013). Since IPOs play an important role in developing successful companies, this topic has received a significant theoretical and empirical research interest since the 1960s (Wang & Wan, 2013). The phenomenon of underpricing was first documented in the early 1970s from Ibbotson (1975) and Logue (1973). Underpricing is defined as the relative difference between the issue price and the price at the end of the first trading day (Ritter & Loughran, 2002; McGough & Smith, 1999; Ritter, 2011). Underpricing can be defined as the state in which the company's shares are traded above the offer price at the IPO. Solely Only the price development of the first trading day after the IPO is considered, thus the percentage difference between the offer price and the closing price of the first-day trading (Ibbotson, 1975). In most IPO cases, the initial issue price at which companies sell their equity is usually below the prevailing price at the end of the first trading day (Ibbotson & Ritter, 1995). Underpricing can be understood as a direct transfer of wealth from the original shareholders to the investors in the stock market (Certo, Covin, Daily, & Dalton, 2001a). In later research, asymmetric information between the different parties involved in an IPO is one of the root causes of underpricing. This can be the occurrence of asymmetric information between the issuer and the investors, the issuer and the underwriter, within the investor group and between the underwriter and investor. However, the basic issue is that there are different levels of information about the

quality and the growth potential of the respective company among the parties which are involved in an IPO (Rock,1986; Beatty & Ritter, 1986; Loughran & Ritter, 2002; Ritter & Welch, 2002).

Most papers focus on theories related to the asymmetric information between the issuer and the investor. A common assumption is that potential investors who have a high degree of uncertainty about the quality and potential of the company will only buy shares if they are at a discount to the expected value of the share price (Rock, 1986). However, even high-quality companies with good performance prospects must be discounted if there are not enough informed investors about selling the required and desired number of shares (Rock, 1986). In general, the greater the uncertainty about the actual price of the new shares, the greater the advantage of the informed investors and the deeper the discount the issuer has to offer to bring enough uninformed investors into the market (Rock, 1986).

2.3. The impact of Venture Capital on the IPO underpricing

This section covers the existing studies on the influence of VC on the underpricing of an IPO. It becomes apparent that there are studies that indicate an increase in underpricing due to the VC, but also studies that show that a VC background can also lead to lower underpricing. Next, the existing evidence regarding the distinction between underpricing of IVC and CVC backed IPOs are discussed.

The first studies on the impact of venture capital on underpricing were conducted by Megginson and Weiss (1991) and Barry et al. (1990). Megginson and Weiss (1991) compared VC backed IPOs with non-sponsored IPOs matched by industry and offering size between January 1983 and September 1987. Their analysis showed that VC backed IPOs had a significantly lower underpricing than the comparable non-sponsored IPOs. The authors argue that this result seems plausible since the role of a VC firm is to know the true value of a company, reducing information asymmetry and thereby underpricing. The authors set up the so-called venture capital certification hypothesis, which states that VC backed companies have increased credibility. Therefore, prestigious underwriters can be recruited for the IPO and the shares of the issuing company can be sold at a higher price which reduces the underpricing. This hypothesis was confirmed by Carter and Manaster (1990) and Lin and Smith (1998). In addition, investors might consider the likelihood of a successful long-term company to be higher once this company is VC backed due to the reputation of VCs to assist their portfolio companies not only financially but also operationally (Wang & Wan, 2013).

Ljungqvist (1999) used the same data set as Megginson and Weiss (1991) to investigate the underpricing of VC backed IPOs. The author likewise concluded that VC backed IPOs show a lower underpricing but justified this result with the incentive of the former shareholders old shareholders to keep the underpricing as low as possible. The former shareholders will pay attention to the issue's pricing and the underwriter's selection to prevent their loss of value through possible underpricing as far as possible. Therefore, Habib and Ljungqvist (2001) assume that underpricing should be lower the more shares of old shareholders are sold.

Another hypothesis to explain the influence of VC on the underpricing of an IPO is the so-called grandstanding hypothesis first mentioned by Gompers (1996) in the paper "Grandstanding in the venture capital industry". This hypothesis states that VC firms aim to take their companies public as quickly as possible to improve their reputation. The VC firms hope for a faster collection of capital of the following fund by the improved reputation (Gompers P. A., 1996). Intending to bring the company as quickly as possible to the stock exchange, the VC firms also accept an endowment of the offer price below the actual value (Lee & Wahal, 2004). As the companies are usually younger and not yet very established, the information asymmetry on the part of the investors regarding the true potential of the company is amplified to an increase in underpricing. The grandstanding hypothesis thus explains an increased underpricing of VC backed IPOs compared to non-sponsored IPOs (Gompers P. A., 1996). This hypothesis is reinforced in the paper "Grandstanding, certification and the underpricing of venture capital-backed IPOs" by Lee and Wahal (2004). The authors conjecture that the return of VC is significantly related to the ability to take their portfolio companies public as quickly as possible. In order to achieve this goal, VC firms are willing to accept a higher underpricing if this increases their reputation. Once established, VCs can raise more and faster capital for future funds and charge higher management fees (Lee & Wahal, 2004).

In the literature to date, numerous studies have been conducted on the influence of VCs on underpricing in IPOs. However, few studies have distinguished between the type of VC and its influence on underpricing in an IPO (Wang & Wan, 2013). Wang and Wan (2013) are one of the few who introduced such a comparison in their analysis. They distinguished between private and corporate VC firms and their impact on IPO underpricing. The authors examined 200 VC-backed IPOs in the period from 2000 to 2007. They wanted to determine the influence of private and corporate VC firms on IPOs underpricing while using OLS regressions. For the OLS regressions, the authors used underpricing as a dependent variable and CVC and IVC as

independent dummy variables as well as quantitative control variables such as firm size, age, and operational profit. They found that CVC-backed IPOs have a lower underpricing.

In contrast, an IVC-backed IPO has a significantly higher underpricing (Wang & Wan, 2013). Wang and Wan (2013) explain their results with the different interests, motivations and contributions to the commercial success of the projects financed by the two VC firms. CVCs are interested in the long-term success of their portfolio companies as they pursue a long-term strategic goal (Dushnitsky & Lenox, 2006). Therefore, CVCs will try to minimize underpricing to reduce the wealth transfer to have as much capital as possible available for the company's further development after the IPO (Platt, 1995; Wang & Wan, 2013). According to Wang and Wan (2013), potential investors are aware of the different interests and motivations of the two VC types. Therefore, a CVC equity stake can be viewed as a positive signal of a listed company's current quality and eventual success, helping to reduce the ex-ante uncertainty of outside investors and the need for a discount to the offering price at the time of the IPO to attract enough drafters (Maula, Autio, & Murray, 2003).

Mogilevsky and Murgulov's (2012), compare the underpricing of private equity-backed, VC-backed, and non-sponsored IPOs. They examined IPOs in 2000-2009 and compared the different initial returns on the first day after the IPO using the difference in means. They found significant differences in underpricing between the three groups PE-backed, VC-backed and non-sponsored IPOs. Using OLS regressions in which the authors added quantitative control variables such as the natural logarithm of assets, the natural logarithm of Age, the natural logarithm of proceeds and the dummy variables PE and VC, they analyzed a significant negative effect PE-backed IPOs on underpricing. In comparison, the VC variable had a positive coefficient which was not significant.

This paper will deal with the same assumptions as in the paper by Wang and Wan (2013). This paper assumes that CVC and IVC firms add different value to their portfolio companies due to their different investment orientations, organizational structure, motivation, and objectives, thus providing different information to investors. Based on these assumptions, the first hypothesis is:

Hypothesis 1: There is a significant difference in the underpricing between IVC and CVC backed IPOs.

Fried and Hisrich (1995) describe that the importance of value-added services provided by IVC firms decreases dramatically once the financed companies have reached an advanced state of

maturity. On the other hand, CVC firms also promote the long-term development of the financed companies after an IPO. This leads to a better signal to investors regarding the successful long-term development of the company after the IPO. Based on this assumption, the second hypothesis of this paper is:

Hypothesis 2: CVC backed IPOs show significant lower underpricing than IVC backed IPOs.

3. Methodology and Data

This part discusses the data collection and methodological process used in this dissertation. Subsequently, the different methods used to test the hypotheses are described.

3.1. Data construction

Different databases such as Thomson Reuters, Wharton Research Data Services (WRDS), Compustat - Capital IQ and Center of Research in Security Prices (CRSP) are used to create the necessary dataset to create the models. The IPO dataset by Jay R. Ritter was used as a basis. In the dataset of Jay R. Ritter, all IPOs of companies founded in the United States from 1975 - 2021 are collected. This dataset contains 14,944 companies. In addition, Jay R. Ritter added a VC dummy variable, which can be used to distinguish between VC backed and non-sponsored IPOs. First, the time of the IPOs to be examined was adjusted to 2000 - 2020 since existing studies have primarily examined IPOs between 1980 - 2007. Thus, the dataset from the present work is significantly more recent than the comparable work from the past. After adjusting the dataset for the years 1975 - 1999, 4,701 IPOs remain in the period 2000 - 2020, of which 3,063 are non-sponsored IPOs, and 1,481 are VC backed IPOs. In accordance with Lee and Wahal (2004), IPOs with an offering price below \$5 were not included. A further distinction in the type of venture capital does not exist in the dataset of Jay R. Ritter, which is why the information to what extent the VC backed IPOs are IVC or CVC backed IPOs had to be obtained from another database. For this purpose, the screener of the Thomson Reuters database was used. However, Thomson Reuters does not only distinguish between CVC and IVC but between a variety of other options. After analyzing the different options, the terms Independent Private Partnership and Corporate or PE/Venture Fund were identified as the respective appropriate declarations for IVC and CVC. Those VC backed companies had to be removed from the dataset that did not have either Independent Private Partnership or Corporate or PE/Venture Fund designations. After removing those IPOs from the dataset that either did not have VC investments at all or for which there is no specification regarding Independent Private

Partnership or Corporate or PE/Venture Fund, a total of 811 VC backed IPOs remain. 712 of them are IVC backed, and 99 are CVC backed IPOs.

After matching IVC and CVC backed IPOs of companies from the United States from 2000 to 2020 by the above-described procedure in the present dataset, these companies' qualitative and quantitative information were collected. This information is essential for the validity of the models applied in this paper. After gathering the Exchange Tickers for all the ventures present in the dataset from Thomson Reuters and WRDS, specifically, Capital-IQ, the data regarding *Sales before the IPO*, *Earnings Before Interest Taxes Depreciation and Amortizations (EBITDA) before the IPO*, *Earnings before Interest & Taxes (EBIT) before the IPO*, *Total Assets before the IPO*, *Earnings per share*, *gross proceeds*, *net proceeds*, *age of the company*, *number of shares*, *two-digit SIC codes*, *offer price*, *the closing price of the first day after the offer*, *net income before the IPO*, *book value before the IPO* and *the headquarter of the company* were able to be collected. However, due to circumstance that certain companies solely publish financial data after the IPO but not before, necessary data points were not available. As a result, the affected companies were removed from the sample. This resulted in an overall sample of 612 VC backed companies, of which 536 are IVC backed and 76 are CVC backed

3.2. Methodology

This section describes the structure of the 3 different models created to specifically analyze the difference in underpricing of CVC backed and IVC backed IPOs This section describes the structure of each model.

3.2.1. OLS-Regression

In the first model, OLS regressions were formed to test the hypotheses. According to Certo et al. (2001b), OLS regression is one of the most frequently used analytical methods in studies of IPO underpricing. In order to additionally measure the different effects based on different subperiods, a regression of the entire period, e.g., from 2000 to 2020, but also in the period from 2000 to 2009 and 2010 to 2020, was formed. Underpricing is the dependent variable, which will be examined in more detail in the following regressions. In most of the literature, the first-day stock returns to subscribing investors are used as a measure of the level of IPO underpricing (Ljungqvist, 2007):

$$UP_i = \frac{P_{i,1} - P_{i,0}}{P_{i,0}}$$

UP_i = Initial returns to subscribing investors (a proxy for underpricing)

$P_{i,1}$ = Closing price on the first day of trading

$P_{i,0}$ = Offering price (subscription price)

Since the difference between CVC backed and IVC backed IPOs is to be investigated, the independent variable is a dummy variable with the value 0 if it is an IVC backed IPO and 1 if it is a CVC backed IPO. In order to construct a regression model that considers the different effects of CVC and IVC backing on IPO underpricing, it is necessary to add a set of control variables that reflect key firm characteristics. This results in the following OLS regression equations:

Full sample:

$$UP_i = \beta_0 + \beta_1 CVC + \beta_2 LN \text{ Net Proceeds} + \beta_3 Operating Profit + \beta_4 LN Age + \beta_5 LN Total Assets + \beta_6 EPS + \beta_7 Industry + \beta_8 \sum_{i=1}^{21-1} Year_i + e_i^b$$

Subperiod 2000 – 2009:

$$UP_i = \beta_0 + \beta_1 CVC + \beta_2 LN \text{ Net Proceeds} + \beta_3 Operating Profit + \beta_4 LN Age + \beta_5 LN Total Assets + \beta_6 EPS + \beta_7 Industry + \beta_8 \sum_{i=1}^{10-1} Year_i + e_i^b$$

Subperiod 2010 – 2020:

$$UP_i = \beta_0 + \beta_1 CVC + \beta_2 LN \text{ Net Proceeds} + \beta_3 Operating Profit + \beta_4 LN Age + \beta_5 LN Total Assets + \beta_6 EPS + \beta_7 Industry + \beta_8 \sum_{i=1}^{11-1} Year_i + e_i^b$$

The variables are defined as follows:

CVC is a dichotomous variable. A value of 1 means that the IPO is CVC-backed. A value of 0 means that the IPO is IVC-backed. Due to the different interests and motivations, a CVC-backed IPO is expected to have a negative impact on underpricing and reduce it (Wang & Wan, 2013).

LN Net Proceeds is the natural logarithm of the net value (Gross proceeds less costs incurred in an IPO) of the proceeds from the IPO. This variable is intended to serve as a proxy for the size of the IPO. Dunbar (2000) found that the larger the IPO, the lower the underpricing. Therefore, a negative relationship between net proceeds and underpricing is expected. Beatty and Ritter (1986) argued that smaller offerings are more speculative than large offerings, and the initial return is higher for small offerings.

Operating profit defined in this paper as Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) has been added as a proxy for company performance. The pre-IPO values were used. It is expected that better performance will have a negative impact on the underpricing, as a better performance should also be accompanied by higher confidence of investors towards the company (Mogilevsky & Murgulov, 2012).

LN Age is the natural logarithm of the number of years between the founding and IPO dates. The variable is intended to be a proxy for the company's maturity. It can be assumed that the older the company, the more significant the information available and consequently, the lower the information asymmetry. Muscarella and Vetsuypens (1989a) showed that older firms have a lower initial return.

LN Total Assets is the natural logarithm of total assets, used as a proxy for company size. It can be assumed that the larger the firm's size, the more information is available and the lower the information asymmetry should be, which in turn should lead to a lower initial return, according to Beatty and Ritter (1986).

EPS (Earnings per Share) is a dichotomous variable with a value of 1 if the company had positive earnings per share before the IPO. The variable serves as a proxy for the performance of the company. It can be assumed that companies with a positive EPS have a lower underpricing as potential investors have more confidence in such a company (Mogilevsky & Murgulov, 2012).

A set of industry dummies were added to control the model for any industry effects. Each company was given a two-digit SIC code.

A set of year dummies was added to control the model for the effects of hot IPO issue markets described by Ritter (1984). For the whole sample for the period from 2000 to 2020 and the two other subperiods from 2000 to 2009 and 2010 to 2020.

3.2.2. Unadjusted first-day return matching

In the following model, the method of Megginson and Weiss (1991) was used. With the model, the authors analyzed the difference in underpricing between VC-backed IPOs and non-VC-backed IPOs. This method is now used to investigate the difference in underpricing between CVC-backed IPOs and IVC-backed IPOs. Each CVC-backed IPO was matched with a single IVC-backed IPO with the same two-digit SIC code and the closest net proceeds value. In addition, the adjustments to Lee and Wahal's (2004) model were adopted. This adjustment

requires that the IVC-backed IPO have taken place within two years of the CVC-backed IPO. Otherwise, it could have happened (in the full sample) that a CVC-backed IPO is matched with an IVC-backed IPO up to 20 years apart. After the matching procedure had been performed, the average initial return of both groups was calculated to measure their difference subsequently. This makes it possible to quantify how the underpricing of CVC-backed IPOs differs from the underpricing of IVC-backed IPOs. This procedure was carried out for 2000 to 2020, with the subperiods 2000 to 2009 and 2010 to 2020.

3.2.3. Propensity Score Matching Procedure

This paper aims to measure the difference in underpricing between CVC backed, and IVC backed companies. Following the notation in Heckman et al. (1998) and Lee and Wahal (2004), Y_1 can be defined as the initial return of an IPO with CVC backing while Y_0 is the initial return for the same IPO with IVC backing and $D = 1$ if the company is CVC backed (zero if it is IVC backed). Thus, $Y_1 - Y_0$ would be what to find out. Logically, this is not measurable since a single company can be either CVC backed or IVC backed. The solution would be to measure the average impact of CVC backing on CVC backed IPOs, $E(Y_1 - Y_0|D = 1, X)$, where X is a vector with different company and industry characteristics. This would be under the following circumstances:

$$E(Y_1 - Y_0|D = 1, X) = E(Y_1|D = 1, X) - E(Y_0|D = 1, X)$$

$E(Y_1|D = 1, X)$ is the average initial return for CVC backed IPOs. $E(Y_0|D = 1, X)$ is the average initial return CVC backed IPOs would experience if they did not receive CVC backing. However, this is not possible under such non-experimental data. Therefore, an alternative approach is to use $E(Y_0|D = 1, X)$ instead, i.e. the average return of IVC backed IPOs.

Since CVC is a non-randomly selected characteristic and an endogenous decision, a bias is present, which can be defined as follows:

$$B(X) = E(Y_0|D = 1, X) - E(Y_0|D = 0, X)$$

The propensity score matching method considers the endogenous decision in a matching framework that allows causal inference in non-experimental contexts. Rubin (1974, 1977) and Rosenbaum and Rubin (1983) proved that matching on $\Pr(D = 1|X)$ can eliminate this bias. To apply the method, an estimation of a probit model for the endogenous variable ($D=1$ for CVC backing and zero for IVC backing) with a vector of X variables has to be created.

The following variables were used to create the probit model regression. As described above, the CVC dummy variable operationalised as the dependent variable with a value of 1 if the company is CVC backed and the value of 0 if the company is IVC backed. In addition, the following instrumental variables were used: Location, Industry dummies, Year dummies, the natural logarithm of age, the natural logarithm of Total Assets, natural logarithm of Net Proceed, Operating profit, EPS dummy, Tech dummy. According to Lerner (1995), the probability of closing an investment round also depends on the company's location. Therefore, a location dummy variable was created that takes the value 1 if the company is located in California or Massachusetts and 0 otherwise. Due to the industry concentration of CVC backed IPOs, an industry variable in the form of the two-digit SIC code was added. A set of year dummies was also added to control the model for the effects of hot IPO issue markets (calendar effects) described by Ritter (1984). As it is evident from the descriptive statistics in Table 1, the CVC backed, and IVC backed companies also differ in age, total assets, net proceeds, operating profit and EPS; therefore, these variables were added. Finally, a tech dummy variable was created, which takes the value 1 if, according to the Venture Economics Industry Codes (VEIC) the company belongs to the technology sector and 0 otherwise. The probit regression with the described variables was performed for the entire period and the subperiods 2000 to 2009 and 2010 to 2020 since these periods are also to be compared in this model.

As a result of the probit model regression, each company receives an individual propensity score, indicating how likely it is that this company will receive CVC backing. Subsequently, a suitable method was used to match the companies with the appropriate propensity scores. This study follows the suggestion by Heckman et al. (1997, 1998) to include a “one-to-many” matching method, also referred to as “kernel estimator”. Each CVC backed IPO is matched with more than one comparable IVC backed IPO in this method. The weighted average of several IVC backed IPOs is used. The difference in underpricing can be measured after matching the CVC backed IPOs with the appropriate IVC backed IPOs.

4. Empirical Analysis of IPO underpricing

The following section presents the results of the models described in the methods section. These model results confirm or reject the hypotheses made at the beginning. Before the results of the models are shown, the collected data set is described in more detail with the help of descriptive statistics.

4.1. Results

Table 1 shows the descriptive statistics of the dataset studied, consisting of 536 IVC backed and 76 CVC backed IPOs from 2000 to 2020. Panel A shows the distribution of CVC backed, and IVC backed IPOs by industry using the two-digit SIC codes. The majority of companies in both CVC-backed and IVC-backed IPOs come from the "Chemicals and Allied Products" (SIC code 28), "Business Services" (SIC code 73) and "Engineering, Accounting, Research and Management Services" (SIC code 87) sectors. In CVC-backed IPOs, around 80.3% of the companies come from these three sectors. In the case of IVC-backed IPOs, the figure is still around 65.5%. Based on this distribution, it can be seen that the industry plays a decisive role in determining whether a company is CVC-backed or not. This fact underlines the assumption that CVC financing is not a random endogenous decision.

Panel B shows the distribution of CVC backed, and IVC backed IPOs over time. Lowry and Schwert (2002) found that there are waves in IPO activity over a period of time. These fluctuations inactivity can also be seen in the current data set. In the first half of the period studied (2000-2009), only about 14.5% of CVC backed IPOs, and only 23.0% of IVC backed IPOs took place. If we exclude the year 2000, in which many IPOs took place due to the dot-com bubble, only about 5.3% of CVC backed, and only 19.0% of IVC backed IPOs took place. Especially in 2001-2003, i.e. directly after the dot-com bubble, and in 2008 and 2009, the number of IPOs was the lowest due to the financial crisis.

Panel C shows the distribution of CVC backed, and IVC backed IPOs by headquarters of the individual companies. Here, most of the companies in the CVC backed and IVC backed IPOs are from California, at about 42.1% and 37.7%, respectively. About 70.0% of the companies in the CVC backed IPOs are from the states of California, Massachusetts, and Pennsylvania. For the companies in the IVC backed IPOs, these three states comprise about 57.8%. According to Lerner (1995), this distribution is not surprising since VC firms generally invest in companies close to their offices to lower monitoring costs. As with the industry distribution, the geographic distribution suggests that the company's location plays a crucial role in whether a company is CVC backed. This again suggests that CVC financing is a non-random endogenous decision.

Panel D shows six firm-level characteristics of CVC and IVC backed IPOs: Firm age, Book value before IPO, Revenue before IPO, EBITDA before IPO, the proportion of positive EPS before IPO and total Assets before IPO. From this data, it can be seen that companies from CVC backed IPOs are younger, generate lower revenues, have lower EBITDA and have a lower

probability of positive EPS with a 1% significance level. Furthermore, CVC backed companies have lower total assets with a 5% significance level. With a 10% significance level, IPOs of CVC backed companies also have a more extensive gross spread and a lower book value.

Table 1. Distribution and characteristics of CVC backed, and IVC backed IPOs/Companies

The sample contains 612 VC-backed companies which went public from 2000 to 2020. 536 companies are IVC-backed from this dataset, while the remaining 76 companies are CVC-backed. Panel A shows the industry distribution of IVC, and CVC backed IPOs across two-digit SIC codes. Panel B shows the geographical distribution of CVC and IVC backed IPOs. Panel C shows the time-series distribution of the CVC and IVC backed IPOs for each calendar year. Panel D provides means of various characteristics of CVC and IVC backed IPOs, along with the associated t-statistics. Net proceeds are in millions of dollars. Age is the average number of years from the founding date to the IPO date. The gross spread is in percent. The book value is millions of dollars prior to the offering date. The revenue is in millions of dollars prior to the offering date. Total assets are in millions of dollars prior to the offering. Earnings per share (EPS) are the share of positive EPS in percent.

2 digit SIC	IVC backed IPOs (%)	CVC backed IPOs (%)	2 digit SIC	IVC backed IPOs (%)	CVC backed IPOs (%)
<i>Panel A: Industry distribution of IVC and CVC backed IPOs</i>					
13	1.12	0.00	50	0.56	1.32
14	0.37	0.00	51	0.75	0.00
17	0.19	0.00	52	0.19	0.00
20	0.37	0.00	54	0.56	0.00
24	0.19	0.00	56	0.56	0.00
25	0.56	0.00	58	1.49	0.00
28	25.75	32.89	59	0.75	1.32
30	0.19	0.00	60	1.31	0.00
32	0.37	0.00	61	0.75	0.00
33	0.19	0.00	62	0.93	0.00
34	0.37	0.00	63	0.93	0.00
35	1.49	1.32	64	0.19	1.32
36	2.99	2.63	65	0.19	0.00
37	0.93	0.00	67	0.75	0.00
38	8.58	3.95	73	26.49	25.00
39	0.00	1.32	75	0.19	0.00
44	0.19	0.00	79	0.19	0.00
46	0.19	0.00	80	3.36	1.32
47	0.00	1.32	82	0.37	0.00
48	1.12	2.63	87	13.25	22.37
49	1.12	1.32	Full sample	100	100

State	IVC backed IPOs (%)	CVC backed IPOs (%)	State	IVC backed IPOs (%)	CVC backed IPOs (%)
<i>Panel B: Geographic distribution of IVC and CVC backed IPOs</i>					
AZ	0.93	0.00	MO	0.19	0.00
CA	37.69	42.11	NB	0.19	0.00
CO	1.49	0.00	NC	2.43	2.63
CT	0.75	2.63	NJ	3.17	3.95
DE	0.37	1.32	NM	0.19	0.00
DL	0.19	0.00	NY	4.66	5.26
FL	1.12	1.32	OH	1.12	0.00
GA	2.05	0.00	OK	0.37	0.00
ID	0.19	0.00	OR	0.37	0.00
IL	1.31	3.95	PA	3.73	5.26
IN	0.75	0.00	SC	0.37	0.00
KY	0.19	0.00	TN	1.12	0.00
LA	0.19	0.00	TX	7.09	1.32
MA	16.42	23.68	UT	1.12	0.00
MD	1.31	1.32	VA	1.87	0.00
ME	0.19	0.00	WA	4.10	3.95
MI	0.75	0.00	WI	0.37	1.32
MN	1.68	0.00	Full sample	100	100

Year	IVC backed IPOs (%)	CVC backed IPOs (%)	Year	IVC backed IPOs (%)	CVC backed IPOs (%)
<i>Panel C: Time-series distribution of IVC and CVC backed IPOs</i>					
2000	3.17	9.21	2011	2.43	1.32
2001	0.56	0.00	2012	2.99	0.00
2002	1.49	1.32	2013	5.97	2.63
2003	1.87	0.00	2014	13.06	5.26
2004	4.29	0.00	2015	9.51	11.84
2005	2.61	0.00	2016	4.48	7.89
2006	3.92	1.32	2017	5.60	7.89
2007	4.48	1.32	2018	7.46	13.16
2008	0.19	0.00	2019	10.07	13.16
2009	0.37	1.32	2020	11.94	22.37
2010	3.54	0.00	Full sample	100	100

	CVC backed IPOs	IVC backed IPOS	
	Mean	Mean	T-statistics
<i>Panel D: Characteristics of CVC and IVC backed IPOs</i>			
Age	7.66	13.83	7.36***
Book value	212.58	481.94	1.72*
Revenue	92.64	377.73	4.72***
EBITDA	-63.85	15.74	3.69***
EPS (%pos.)	0.08	0.23	5.66***
Total Assets	263.94	873.24	2.05**
Net proceeds	202.42	198.98	0.07
Gross spread	13.33	10.06	1.79*
*** Significance for the t-test of differences in means at the 1% level			
** Significance for the t-test of differences in means at the 5% level			
* Significance for the t-test of differences in means at the 10% level			

Having presented the basic descriptive statistics of the dataset, the results of the three different models used to measure the difference between CVC backed IPOs and IVC backed IPOs in terms of underpricing are presented.

First, the results of the applied OLS regressions are shown. Table 2 lists the bivariate Pearson correlations between the explanatory and dependent variables. There is apparent collinearity between the two independent variables LN Net Proceeds and LN Total Assets, with a correlation coefficient of 0.72. This collinearity is controlled by an alternative combination of explanatory variables outlined below.

Table 2. Correlation matrix

The sample contains 612 VC-backed companies which went public from 2000 to 2020. 536 companies are IVC-backed from this dataset, while the remaining 76 companies are CVC-backed. Table 2 shows the correlation coefficients of the different variables which were used for the OLS regressions.

	Underpricing	CVC dummy	LN Net Proceeds	Operating profit	LN Age	LN Assets	EPS dummy	Industry dummy	Year dummy
Underpricing	1.00								
CVC dummy	0.02	1.00							
LN Net Proceeds	0.20	0.02	1.00						
Operating profit	-0.04	-0.08	0.13	1.00					
LN Age	-0.01	-0.17	0.19	0.26	1.00				
LN Assets	0.10	-0.02	0.72	0.27	0.29	1.00			
EPS dummy	-0.01	-0.14	0.09	0.17	0.29	0.27	1.00		
Industry dummy	0.14	0.02	0.21	0.00	0.03	0.19	0.03	1.00	
Year dummy	0.06	0.11	0.29	-0.07	-0.12	0.03	-0.33	0.14	1.00

For the OLS regressions, robust standard errors are reported robust to homoscedasticity deviations. In addition, the variance inflation factor (VIF), which is widely accepted, was applied to test for multicollinearity (Craney & Surles, 2002). None of the values exceeded the usual threshold of 10. Except for the variables LN Net Proceeds (3.46) and LN Asses with (3.73), all values are below 2.5. Thus, it can be assumed that multicollinearity is not a problem in the present study (William Netter, Kutner, & Wasserman, 1985). However, what is clear from the correlation matrix in Table 2 is that there is collinearity between the variables LN Net Proceeds and LN Assets (correlation coefficient of 0.72), as described earlier. An additional combination of variables was used for the OLS regressions to control this correlation.

Table 3. OLS Regressions to test the impact of CVC backing on the underpricing of an IPO

The sample contains 612 VC-backed companies which went public from 2000 to 2020. 536 companies are IVC-backed from this dataset, while the remaining 76 companies are CVC-backed. Model 1a consists of the data for the entire time horizon from 2000 to 2020 (612 observations). In order to control for the relationship between the variables LN Net Proceeds and LN Total Assets, the variable LN Net Proceeds was removed in Model 1b. In Model 2a, the OLS regression was created for the period from 2000 to 2009 (134 observations). In model 2b, the variable LN Net Proceeds was again eliminated to avoid collinearity with the variable LN Total Assets. Finally, in model 3a, an OLS regression was created from 2010 to 2020 (478 observations). Again, to avoid collinearity, the LN Net Proceeds variable was eliminated in model 3b. Robust standard errors are in parentheses.

Variables	Model 1a	Model 1b	Model 2a	Model 2b	Model 3a	Model 3b
CVC dummy	-0.06 (0.05)	-0.05 (0.05)	-0.39** (0.18)	-0.39** (0.18)	-0.02 (0.05)	-0.01 (0.06)
LN Net Proceeds	0.11*** (0.03)		0.06 (0.08)		0.13*** (0.03)	
Operating profit	-0.00003 (0.00007)	-0.00004 (0.00006)	-0.0001 (0.0005)	-0.00008 (0.0005)	-0.00003 (0.00007)	-0.00005 (0.00006)
LN Age	-0.04** (0.02)	-0.04* (0.02)	-0.08** (0.04)	-0.07* (0.04)	-0.03 (0.03)	-0.032 (0.01)
LN Assets	-0.02 (0.02)	0.03** (0.01)	0.05 (0.08)	0.07 (0.06)	-0.03* (0.02)	0.03** (0.01)
EPS	-0.03 (0.05)	-0.04 (0.05)	0.02 (0.12)	0.02 (0.12)	-0.09 (0.06)	-0.11* (0.06)
Industry	Included	Included	Included	Included	Included	Included
Year	Included	Included	Included	Included	Included	Included
Constant	0.24 (0.22)	0.40 (0.20)	0.09 (0.39)	0.20 (0.40)	-0.35 (0.17)	-0.02 (0.12)
R-squared	0.26	0.23	0.41	0.40	0.29	0.26
Number of observations	612	612	134	134	478	478

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

The results of the OLS regressions shown in table 3 of Model 1a and 1b and thus for the entire period from 2000 to 2020 indicate that CVC backed IPOs have a different impact on underpricing than IVC backed IPOs. To validate the hypotheses 1 and 2, the CVC dummy in model 1a and 1b will be scrutinized. The results show a negative coefficient for both models (1a = -0.06; 1b = -0.05). Due to the nature of the CVC variable being a dummy, a negative coefficient indicates that CVC backed IPOs exhibit a lower underpricing than IVC backed IPOs. However, the coefficient are not significant. As a result, the first hypothesis that the underpricing of CVC backed IPOs differs from IVC does not hold. Likewise, hypothesis 2, which states that CVC backed IPOs have a lower underpricing, is rejected. The OLS regressions of models 2a and 2b for the subperiod 2000 to 2009 show negative coefficients of -0.39. This result corresponds to the result from the first two regressions. However, in contract to model 1,

the CVC dummies show significance at a 5% level this time. Thus, hypothesis 1 can be accepted that CVC backed IPOs have a different underpricing than IVC backed IPOs. Due to the negative coefficients, hypothesis 2 can also be accepted, i.e. that CVC backed IPOs have a lower underpricing than IVC backed IPOs. However, models 3a and b for the subperiod 2010 to 2020 confirm the results of models 1a and b. Although the CVC dummy variable coefficients are negative at -0.02 and -0.01, they are not significant. Therefore, hypotheses 1 and 2 have to be rejected for this period. We have to assume that there is no difference in the underpricing of CVC backed and IVC backed IPOs.

After examining the distribution and characteristics of CVC backed firms in Table 1, it was found out that it is very likely that CVC financing is a non-random endogenous decision, and the OLS regressions are likely to have a selection bias. To test the results of the OLS regressions, the results of the two models that control for an appropriate selection bias are shown.

First, the models were adapted from Megginson and Weiss (1991) and Lee and Wahal's (2004) adjustments to measure the difference in the underpricing of CVC backed, and IVC backed IPOs, as shown in table 4, are analyzed.

**Table 4. Test for differences in underpricing of CVC-Backed and IVC-Backed IPOs
Unadjusted first-day returns for CVC backed and "matched" IVC backed IPOs.**

Initial first-day returns are calculated as the percentage change in price from the offer to the stock's closing price on the first day of trading. Raw first-day returns are presented for CVC backed IPOs. For IVC backed IPOs, only "matched" returns are presented. Considering the method of Megginson and Weiss (1991), each CVC backed IPO is matched with a (single) IVC backed with the closest net proceeds and the same two-digit SIC code. The matching procedure also requires that the IVC backed IPO take place between two years before and two years after the CVC backed IPO. Statistics are represented for the full sample of IPOs from 2000 to 2020. Subperiods are also presented, such as from 2000 to 2009 and 2010 to 2020. The year 2000 is also displayed, as this is interesting, especially concerning the technology bubble during this period.

Sample	CVC backed IPOs		IVC backed IPOs	Return difference	T-statistic
	Number of IPOs	First-day return	"Matched" first-day return		
Full sample (2000-2020)	76	0.27	0.35	-0.08	-1.13
Subperiods					
2000-2009	11	0.18	0.67	-0.48	-2.40**
2010-2020	65	0.29	0.30	-0.01	-0.14
2000	7	0.19	0.95	-0.76	-3.08***

*** Significance for the t-test of differences in means at the 1% level

** Significance for the t-test of differences in means at the 5% level

* Significance for the t-test of differences in means at the 10% level

The average first-day return of CVC backed IPOs over the entire period from 2000 to 2020 is around 27.0%. The average first-day return for the "matched" IVC backed IPOs is around 35.0%. Thus, the underpricing of CVC backed IPOs is on average about 8.0% lower for the entire period. This result would confirm hypothesis 1 that there is a difference in underpricing between CVC backed and IVC backed IPOs and hypothesis 2 that CVC backed IPOs have a lower underpricing than IVC backed IPOs. However, when looking at the significance for the t-test in means, the result is not significant, and hypotheses 1 and 2 have to be rejected for the entire observation period 2000 to 2020. The same result applies to the subperiod from 2010 to 2020, where the average first-day return of CVC backed IPOs is around 29.0% and of IVC backed IPOs around 30.0%. Consequently, the difference is just 1.0% which is not significant.

For the subperiod from 2000 to 2009, the average first-day return of CVC backed IPOs is around 18.0%.

The average first-day return of the "matched" IVC backed IPOs is around 67.0%, which means a difference of around 49.0%. This result is significant for the t-test of differences in means at a 5% level. Thus, hypothesis 1, that CVC backed IPOs and IVC backed IPOs are different, and hypothesis 2, that CVC backed IPOs has lower underpricing than IVC backed IPOs, can be accepted. However, this significant result in the subperiod from 2000 to 2009 can also be explained by the year 2000. In that year, the average first-day return of CVC backed IPOs was just 19.0%. In comparison, the average first-day return of IVC backed IPOs was around 95.0%, a difference of 76.0%. This result is significant for the t-test of differences in means at a 1% level.

Finally, the results of the third model, the propensity score approach, are presented. In order to determine a propensity score for each company, probit model regressions were created for the entire period (2000 to 2020), as well as for the subperiods 2000 to 2009 and 2010 to 2020. These probit model regressions were built based on some independent variables that have explanatory power for the probability of why a company is CVC backed, which is the dependent variable of the probit model regressions. After determining the propensity score for each company in the different periods using the probit model regressions, CVC backed, and IVC backed companies were matched using a one-to-many method (kernel method described in more detail in the methods section). Looking at the probit model regressions results in panel A of Table 5, it is clear that the variables Age and EPS have a significant impact on whether a company is CVC backed. Companies that are younger and have a lower EPS are more likely to be CVC backed.

**Table 5. Test for differences in underpricing of CVC-Backed and IVC-Backed IPOs
Probit Model Regressions and Selection bias-adjusted initial return differences**

The sample contains 612 VC-backed companies which went public from 2000 to 2020. 536 companies are IVC-backed from this dataset, while the remaining 76 companies are CVC-backed. Panel A shows the results of the probit model regressions for the full sample (2000 to 2020) and the subperiods from 2000 to 2009 and 2010 to 2020. In these regressions, the dependent variable was the CVC dummy variable, with a value of 1 if the firm is CVC backed and 0 otherwise. Two-sided *p*-values are in parentheses. Panel B represents the selection bias-adjusted initial returns (underpricing) of unmatched CVC backed, and IVC backed IPOs and the difference between them for the entire period from 2000 to 2020 (612 observations). The row below shows the selection bias-adjusted initial returns (underpricing) of CVC backed IPOs and IVC backed IPOs resulting from the propensity score matching approach and their difference. Panel C represents the selection bias-adjusted initial returns (underpricing) of unmatched CVC backed, and IVC backed IPOs and their difference for the subperiod from 2000 to 2009 (134 observations). The row below shows the selection bias-adjusted initial returns (underpricing) of CVC backed IPOs and IVC backed IPOs resulting from the propensity score matching approach and their difference. Panel D represents the selection bias-adjusted initial return (underpricing) of unmatched CVC backed, and IVC backed IPOs and their difference for the subperiod from 2010 to 2020 (478 observations). The row below shows the selection bias-adjusted initial returns (underpricing) of CVC backed IPOs and IVC backed IPOs resulting from the propensity score matching approach and their difference.

<i>Panel A. Probit Model Regressions</i>			
Independent variables	Coefficient Estimates (p-values)		
	Full sample	2000-2009	2010-2020
Intercept	0.05 (0.93)	2.69 (0.22)	-0.58 (0.38)
Location	-0.06 (0.73)	-0.09 (0.89)	-0.09 (0.63)
LN Age	-0.46 (0.00)	-1.64 (0.03)	-0.34 (0.03)
LN Assets	-0.05 (0.64)	-0.49 (0.25)	-0.08 (0.49)
LN Net Proceeds	0.16 (0.28)	0.69 (0.17)	0.17 (0.31)
Operating profit	-0.0001 (0.72)	-0.02 (0.05)	-0.0001 (0.75)
EPS	0.63 (0.08)	0.85 (0.39)	-0.92 (0.08)
Tech	-0.26 (0.36)	-0.77 (0.35)	-0.34 (0.35)
Year	Included	Included	Included
Industry	Included	Included	Included
Pseudo-R ²	0.12	0.40	0.1
Prob > chi-squared	0.01	0.08	0.09
Number of observations	612	134	478

<i>Panel B. Full Sample</i>				
Dependent Variable	CVC IPOs	IVC IPOs	Difference	p-value
Underpricing (unmatched)	0.27	0.26	0.01	0.83
Underpricing (matched)	0.28	0.31	-0.03	0.61
<i>Panel C. 2000-2009</i>				
Underpricing (unmatched)	0.18	0.33	-0.15	0.42
Underpricing (matched)	0.22	0.57	-0.35	0.13
<i>Panel D. 2010-2020</i>				
Underpricing (unmatched)	0.27	0.25	0.02	0.71
Underpricing (matched)	0.28	0.29	-0.01	0.90

Panel B shows the average difference in underpricing between CVC-backed and the propensity score-matched IVC-backed IPOs for the entire sample. The difference is around 3.0%. The average underpricing of CVC backed IPOs is around 28.0%, and that of IVC backed IPOs around 31.0%. IPOs thus show an average lower underpricing than the comparable IVC backed IPOs. This suggests that the hypotheses of this paper can be confirmed. However, the average difference in underpricing is not significant, with a p-value of 0.61. Thus, hypothesis 1 has to be rejected that the underpricing of CVC backed and IVC backed IPOs are different. Hypothesis 2 that CVC backed IPOs have a lower underpricing than IVC backed IPOs must also be rejected. Panel C shows the average underpricing of CVC backed IPOs in the period from 2000 to 2009 was around 22.0%.

The average underpricing of IVC backed IPOs matched by the propensity score method was around 57.0%. Thus, the average underpricing of CVC backed IPOs for this period was around 35.0% lower. Despite the large difference, when considering the p-value of 0.13, the result is only slightly significant. Thus, hypothesis 1, that the underpricing of CVC backed and IVC backed IPOs are different, can be accepted only with a slight significance at a p-value of 0.13. The same applies to hypothesis 2, which states that the underpricing of CVC backed IPOs is lower than the underpricing of IVC backed IPOs. Panel D compares the average underpricing of CVC-backed IPOs and IVC-backed IPOs matched by the propensity score method from 2010 to 2020. CVC-backed IPOs have an average underpricing of 28.0%. The matched IVC backed IPOs have an average underpricing of 29.0%. Therefore, the difference between the underpricing of the CVC backed and the IVC backed IPOs is not significant for this period.

Both hypotheses must therefore be rejected. It cannot be concluded that there is a difference between the underpricing of CVC backed and IVC backed IPOs.

5. Robustness Tests

To stress the results of the models used in this paper, several robustness tests were conducted. These refer to the OLS regressions, the matching method according to Megginson and Weiss (1991), and the propensity score method. First, the entire time period was divided into different subperiods in order to check to what extent the results are similar or different with respect to the different time periods. Significant differences were found in the results of all three models as shown in Table 3, 4 and 5. For the entire sample from 2000 to 2020 and the subperiod from 2010 to 2020, no significant differences in underpricing between CVC backed and IVC backed IPOs could be identified in all three models. The OLS regressions and the matching method according to Megginson and Weiss (1991) reveal singularly lower underpricing for CVC backed IPOs compared to IVC backed IPOs only for the subperiod from 2000 to 2009.

For each of the OLS regressions, robust standard errors were utilized to homoscedasticity deviations. In addition, the variance inflation factor (VIF), which is widely accepted, was applied to test for multicollinearity (Craney & Surles, 2002). None of the values exceeded the usual threshold of 10. Except for the variables LN Net Proceeds (3.46) and LN Assets with (3.73), all values are below 2.5. Thus, it can be assumed that multicollinearity is not a problem in the present study (William Netter, Kutner, & Wasserman, 1985). From the covariance matrix, it became apparent that there could be collinearity between the two control variables LN Net Proceeds and LN Assets with a correlation coefficient of 0.72. Therefore, any OLS regression for the three different time periods was run once with all variables and once without the LN Net Proceeds variable. From the results of Table 3 both types of models (with and without LN Net Proceeds) show similar results.

To ensure that the difference in underpricing between CVC backed and IVC backed IPOs is not influenced by the choice of instrumental variables and the final matching method, several combinations of instrumental variables and different matching methods in the propensity score matching method were used. First, the instrumental variables Tech, LN Assets and Location were added. The results of the difference in underpricing between CVC backed and IVC backed IPOs were similar to those of the model in which all instrumental variables listed in Table 5 were applied. However, the pseudo R^2 and hence the explanatory power of the CVC variables was significantly lower compared to the model in Table 5 with all instrumental variables. This

is the reason why all instrumental variables listed in Table 5 were used. In order to additionally ensure that the matching method used does not influence the results, alternative matching methods were applied, such as the Epanechnikov kernel method. However, the matching method has no influence on the results obtained.

6. Main results

Finally, after the different models have been run and the general results described, the authoritative results of the present study are summarized. Subsequently, these results are compared with the results of the relevant literature.

Firstly, it can be said that CVCs invest in smaller, younger and less profitable companies than IVCs. The first two models, the OLS regressions and the unadjusted first-day return comparison according to Megginson and Weiss (1991), yielded almost identical results. Both models found a significant difference between the underpricing of CVC backed IPOs and IVC backed IPOs from 2000 to 2009. For this period and with the help of these two models, hypothesis 1 that there is a difference in underpricing between CVC backed and IVC backed IPOs can be accepted. Also, hypothesis 2, that CVC backed IPOs have lower underpricing than IVC backed IPOs, can be confirmed. The result of these two models is also consistent with the paper by Wang and Wan (2013). They proved the negative influence of CVC financing compared to IVC financing on underpricing using OLS regressions. Their paper examined a period from 2000 to 2007 that was almost identical to the subperiod from 2000 to 2009 in this paper. The available results from the propensity score approach, which considers the non-random endogenous decision of CVC backing, also show a lower underpricing of CVC backed IPOs than IVC backed IPOs for 2000 to 2009. However, this difference is not significant in this model.

For the entire period from 2000 to 2020, all three models used in this study show a slightly lower underpricing of CVC backed IPOs compared to IVC backed IPOs, but these results are consistently not significant. The same can be confirmed for the subperiod from 2010 to 2020, where there is almost no difference in underpricing between CVC backed, and IVC backed IPOs. From the above results, it can be concluded that the difference in underpricing between CVC-backed IPOs and IVC-backed IPOs has decreased over time. While two of the three models used in the paper were able to show a significant difference between the underpricing of CVC backed and IVC backed IPOs in the period from 2000 to 2009, the difference is no longer measurable in the period from 2010 to 2020.

7. Limitations and Further Research

In this section, the limitations of this research, especially concerning the dataset, will be discussed. Subsequently, suggestions are given as to which further studies could be based on the present work.

The dataset by Jay R. Ritter used as a basis only represents the IPO market from 1975 to 2020 of companies from the United States. Even though this market is probably the most relevant in the world, it would be necessary to create a dataset that represents the global IPO market, including companies from Europe, Asia, Australia and Africa, in order to be able to make a statement regarding the influence and the difference of the underpricing of CVC backed, and IVC backed IPOs. In Jay R. Ritter's dataset, those companies that received VC financing were reported with a VC dummy variable. Unfortunately, it was impossible to obtain the more precise distinction between IVC and CVC from the Thomson Reuters database for each of these companies, which significantly reduced the dataset. In order to have a more extensive dataset available for future research, it would be helpful to find a more accurate description of the type of VC (IVC or CVC) for a larger number of VC-backed companies. Future research can pick up the limited access of this study and use a databank that shows greater granularity. A clear imbalance can be seen when looking at CVC backed and IVC backed IPOs.

Of the 612 VC backed IPOs surveyed, just 76 are CVC backed. This is partly because there are generally significantly more IVC backed IPOs. While it would be better to have a more balanced dataset with more CVC backed IPOs, this limitation has been partially balanced by using two different matching methods in this paper. Another reason why the number of companies in the existing dataset was reduced during the process was the inconsistency of the existing company data regarding financial ratios and other company characteristics such as company age. Although several databases, such as the WRDS platform, particularly Compustat-IQ and CRSP, and Thomson Reuters Eikon, were used to obtain this data. Furthermore, it was not always clear which point in time to choose for the financial data since it had to be used before the actual IPO. In addition, the quality of the financial data has to be doubted in some cases, as they differed slightly from database to database. The results of two of the three models show significant lower underpricing of CVC backed IPOs compared to IVC backed IPOs for the period from 2000 to 2009. This difference may be the difference in the interests, motivation and resources of the two VC types, as already found in the analyses of Wang and -Wan (2013). For the whole period from 2000 to 2020 and especially from 2010 to

2020, no significant differences in the underpricing of CVC backed, and IVC backed IPOs could be analyzed. A detailed explanation of why the difference in underpricing is no longer significant for the more recent period from 2010 to 2020 compared to the older period from 2000 to 2009 cannot be provided in this paper. This would be a suitable starting point for further analysis. What has changed in the period from 2010 onwards so that there is no longer a significant difference in the underpricing of CVC-backed versus IVC-backed IPOs compared with the older period.

8. Conclusion

The objective of this study was to analyze whether there is a difference in underpricing between CVC backed and IVC backed IPOs. For this purpose, a sample of CVC backed and IVC backed IPOs was constructed for the period from 2000 to 2020 of companies based in the United States. This sample consists of 612 VC backed IPOs, of which 76 are CVC backed and 536 are IVC backed. Using OLS regressions, a matching method developed by Megginson and Weiss (1991), and a propensity score matching method, the differential impact of CVC backing and IVC backing on underpricing in an IPO were examined. The OLS regressions and the matching method of Megginson and Weiss (1991) showed a significant difference in underpricing between CVC backed and IVC backed IPOs for the period from 2000 to 2009. The underpricing of CVC backed IPOs is significantly lower than the underpricing of IVC backed IPOs for this period. Although the propensity score matching results also showed a lower underpricing of CVC backed IPOs than IVC backed IPOs, these results were not significant. For the entire period from 2000 to 2020 and the subperiod from 2010 to 2020, all models showed no significant difference in underpricing between CVC backed, and IVC backed IPOs.

Overall, the study results thus show that the difference in the influence of CVC and IVC backing on underpricing in an IPO has changed over time. While there was still a significant difference from 2000 to 2009, this difference is no longer present in the more recent period from 2010 to 2020. This result leaves open the question of what exactly is the reason why the difference has decreased over time and is no longer present. This is an excellent starting point for further research in this area.

9. References

- Barry, C., Muscarella, C., Peavy, J., & Vetsuypens, M. (1990). The role of venture capital in the creation of public companies: evidence from going-public process. *The Journal of Law and Economics*, pp. 447-472.
- Berger, A. N., & Udell, G. F. (1998). The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle. *Journal of Banking & Finance*, pp. 613-673, 22.
- Black, B., & Gilson, R. (1998). Venture capital and the structure of capital markets. *Journal of Financial Economics*, pp. 243-277, 47(3).
- Carter, R., & Manaster, S. (1990). Initial Public Offerings and Underwriter Reputation. *Journal of Finance*, pp. 1045-1067, Vol. 45, No. 4.
- Certo, S., Daily, C., & Dalton, D. (2001b). Signaling firm value through board structure: an investigation of initial public offerings. *Entrepreneurship Theory and Practice*, pp. 33-50, 26(2).
- Certo, S., Covin, J., Daily, C., & Dalton, D. (2001a). Wealth and the effects of founder management among IPO-stage new ventures. *Strategic Management Journal*, pp. 641-658, 22(6/7).
- Chesbrough, H. (2002). Making sense of corporate venture capital. *Harvard Business Review*, pp. 90-99, 80.
- Craney, T. A., & Surles, J. G. (2002). Model-Dependent Variance Inflation Factor Cutoff Values. *Quality Engineering*, pp. 391-403, Vol 14.
- Cumming, D., & Johan, S. (2012). *Is Venture Capital in Crisis?* Retrieved from World Economic Review: <http://www.worldfinancialreview.com/?p=1563>
- Dunbar, C. (2000). Factors affecting investment bank initial public offering market share. *Journal of Financial Economics*, pp. 3-41, 55(1).
- Dushnitsky, G., & Lenox, M. J. (2006). When does corporate venture capital investment create firm value? *Journal of Business Venturing*, pp. 753-772.

- Fried, V., & Hirsch, R. (1995). The venture capitalists: a relationship investor. *California Management Review*, pp. 101-113, 37(2).
- Gompers, P. A. (1996). Grandstanding in the venture capital industry. *Journal of Financial Economics*, pp. 133-156, 42.
- Gompers, P., & Lerner, J. (1998). Venture Capital Distributions: Short-Run and Long-Run Reactions. *The Journal of Finance*, pp. 2161-2183, Volume 53, Issue 6.
- Gompers, P., & Lerner, J. (2000). The Determinants of Corporate Venture Capital Success. In R. K. Morck, *Concentrated Corporate Ownership* (pp. 17-53). Chicago, IL: University of Chicago Press.
- Gorman, M., & Sahlman, W. A. (1989). What do Venture Capitalists do? *The Journal of Business Venturing*, pp. 231-248.
- Heckman, J., Ichimura, H., & Todd, P. (1997). Matching as an econometric evaluation estimator: evidence from evaluating a job training program. *Review of Economic Studies*, pp. 605-654, 64.
- Heckman, J., Ichimura, H., & Todd, P. (1998). Matching as an econometric evaluation estimator. *Review of economic studies*, pp. 57-76, 29.
- Hellmann, T. (2002). A theory of strategic venture investing. *Journal of Financial Economics*, pp. 285-314, 64(2).
- Ibbotson, R. G. (1975). "Price Performance of Common Stock New Issues.". *Journal of Financial Economics* 2, pp. 235-272.
- Ibbotson, R. G., & Ritter, J. R. (1995). "Initial Public Offerings.". *Handbooks in Operations Research and*, pp. 993-1016.
- Lee, P. M., & Wahal, S. (2004). Grandstanding, certification and the underpricing of venture capital backed IPOs. *Journal of financial economics*, pp. 375-407, 73.
- Lerner, J. (1995). Venture Capitalists and the Oversight of Private Firms. *The Journal of Finance*, pp. 301-308, 50.
- Lin, T. H., & Smith, R. L. (1998). Insider Reputation and Selling Decisions: The Unwinding of Venture Capital Investments during Equity IPOs. *Journal of Corporate Finance*, pp. 241-263, Vol. 4.

- Ljungqvist, A. (2007). Chapter 7 - IPO underpricing. In E. B. Eckbo, *Handbook of Empirical Corporate Finance* (pp. 375-422). New Hampshire, USA: Tuck School of Business, Dartmouth College, Hanover, New Hampshire, U.S.A.
- Logue, D. (1973). On the pricing of unseasoned equity issues. *Journal of Financial and Quantitative Analysis*, pp. 91-103, 8.
- Lowry, M., & Schwert, G. (2002). IPO market cycles: bubbles or sequential learning. *Journal of finance*, pp. 1171-1200, 57.
- Maula, M., Autio, E., & Murray, G. (2003). Prerequisites for the creation of social capital and subsequent knowledge acquisitions in corporate venture capital. *Venture Capital*, pp. 117-134, 5.
- Maula, M., Autio, E., & Murray, G. (2005). Corporate Venture Capitalists and Independent Venture Capitalists: What do they know, who do they know and should entrepreneurs care? *Venture Capital: An international Journal of Entrepreneurial Finance*, pp. 3-21.
- McGough, R., & Smith, R. (1999). IPO issuers don't mind money left on the table. *The Wall Street Journal*, pp. C1-C2.
- Meggison, W. L. (2004). Toward a Global Model of Venture Capital? *Journal of Applied Corporate Finance*, pp. 89-107, 16(1).
- Meggison, W., & Weiss, K. (1991). Venture capitalist certification in initial public offerings. *Journal of Finance*, pp. 879-903.
- Metrick, A., & Yasuda, A. (2021). *Venture capital & the finance of innovation*. New Jersey: John Wiley & Sons, Inc.
- Mogilevsky, V., & Murgulov, Z. (2012). Underpricing of private equity backed, venture capital backed and non-sponsored IPOs. *Investment Management and Financial Innovations*, pp. 47-59.
- Muscarella, C. J., & Vetsuypens, M. R. (1989a). A simple test of Barons's model of IPO underpricing. *Journal of financial economics*, pp. 125-135, 24.
- Park, H. D., & Steensma, H. K. (2013). The Selection and Nurturing Effects of Corporate Investors on New Venture Innovativeness: Role of Corporate Investors on New Venture Innovativeness. *Strategic Entrepreneurship Journal*, pp. 311-330, 7(4).

- Platt, H. (1995). A note on identifying likely IPO bankruptcies: a symbolic paradox. *Journal of Accounting, Auditing & Finance*, pp. 71-79, 10.
- Ritter, J. R. (1984). The "Hot Issue" Market of 1980. *The Journal of Business*, pp. 215-240, Vol 57 No. 2.
- Ritter, J. R. (2011). Equilibrium in the initial public offering market. *Annual Review of Financial Economics*, pp. 347-374, 3.
- Ritter, J. R., & Beatty, R. P. (1986). Investment banking, reputation and the underpricing of initial public offerings. pp. 213-232, Vol 15.
- Ritter, J. R., & Loughran, T. (2002). Why don't issuers get upset about leaving money on the table in IPOs? *The review of financial studies*, pp. 413-444, Vol 15.
- Ritter, J. R., & Welch, I. (2002). A Review of IPO activity, pricing and allocations. *Yale ICF working paper No. 02-01*.
- Rock, K. (1986). Why new issues are underpriced. *Journal of Financial Economics*, pp. 187-212.
- Rosenbaum, P., & Rubin, D. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, pp. 41-55.
- Smith, D. (2005). The exit structure of venture capital. *UCLA Law Review*, pp. 314-356, 53.
- Wang, X. A., & Wan, W. P. (2013). Explaining the variance in underpricing among venture capital-backed IPOs: A comparison between Private and Corporate VC firms. *Strategic Entrepreneurship Journal*, pp. 331-342.
- William Netter, J., Kutner, M. H., & Wasserman. (1985). *Applied Linear Statistical Models 2nd edition: Regression, Analysis of Variance, and Experimental Designs*. Homewood, IL: Irwin.