Norwegian School of Economics
Bergen, Spring, 2023

Underpricing and long-run performance of Norwegian initial public offerings

An empirical investigation of factors that impacts short and long-term returns of Norwegian initial public offerings

Andreas Nystad & Mathias Hungnes Aass

Supervisor: Tore Leite

Master thesis, MSc in Economics and Business Administration, Financial Economics

NORWEGIAN SCHOOL OF ECONOMICS

Abstract

In this master's thesis, we have investigated several factors that could account for the underpricing and long-term performance of initial public offerings in Norway. We used size, equity beta, and a PE/VC dummy variable as explanatory factors for underpricing. We extended the Fama-French (1992) multifactor model to account for liquidity and momentum in the long-run performance. We also utilize both cumulative abnormal returns (CAR) and buy-and-hold returns (BHR) for the long-run analysis.

Our findings show that PE/VC-sponsored IPOs are more underpriced, but not at a statistically significant level. Size and risk do not impact the level of underpricing at a statistically significant level either. In terms of long-run performance, CAR exhibits underperformance of PE/VC-sponsored IPOs, with smaller firms underperforming to a larger extent. BHR results vary drastically over time between PE/VC and non-sponsored firms, but this seems to be a result of market dynamics as opposed to sponsoring. None of the risk-adjusted models return significant alphas, but value-weighted portfolios indicate slight underperformance for PE/VC-sponsored IPOs. Covid-19 also had an influence on our results, as PE/VC-sponsored IPOs significantly outperformed non-sponsored IPOs for a short duration. Lastly, both equally- and value-weighted portfolios' market exposure was influenced by the pandemic.

Acknowledgements

We would like to thank our supervisor, Professor Tore Leite, for his knowledgeable input and feedback on our thesis. We are also grateful to Associate Professor Carsten Bienz for assisting us with obtaining sponsoring data from Argentum.

Finally, we would like to express a big thank you to our friends and family for your endless support during the writing of our master's thesis.

Contents

1. Introduction

The initial public offering (IPO) process is an interesting subject, with known phenomena that tend to occur in the short and long term. Every country with a stock market has underpricing, which is when the original offering price is lower than the first-day closing price (Loughran, Ritter, & Rydqvist, 1994). While the research on long-run performance is not as unified, IPOs tend to underperform the market (Berk & DeMarzo, 2020). Our interest in this subject, paired with an interest in Private Equity (PE) and Venture Capital (VC) led to our decision of pursuing this topic with an up-to-date Norwegian perspective.

PE and VC funds have seen a rise in recent years, going from managing $100 billion in 1994 (Metrick & Yasuda, 2011) to $2.4 trillion in 2015 (Preqin, 2016). Given this context, we aim to investigate if firms sponsored by PE or VC would perform differently from non-sponsored firms as they provide operational, strategic, and financial expertise. Additionally, we explore how risk and size factors affect the performance of IPOs in the short term. In the long term, we expand upon the Fama-French (1992) multifactor model with liquidity and momentum factors.

Our dataset is based on the listing changes on the Norwegian stock exchanges from 2010 to 2020. We obtained a list of PE/VC-sponsored firms from Argentum, which allowed us to distinguish the sponsoring of each IPO.

There is a growing body of research on underpricing and long-term underperformance, and Føllesdal & Hagen (2013) performed a similar analysis on IPOs on the Oslo Stock Exchange from 1996 to 2010. We intend to add to the current body of research by including listings on all Norwegian exchanges, with a more up-to-date time frame.

The outline of our thesis is as follows: section two will outline relevant theories on PE/VC and IPOs, while section three will cover previous literature on underpricing and long-run performance. Section four consists of our hypotheses and section five contains the methodology used in the analysis as well as biases. Section six contains our analysis, while section seven summarizes our findings and covers limitations and future research.

2. Theory

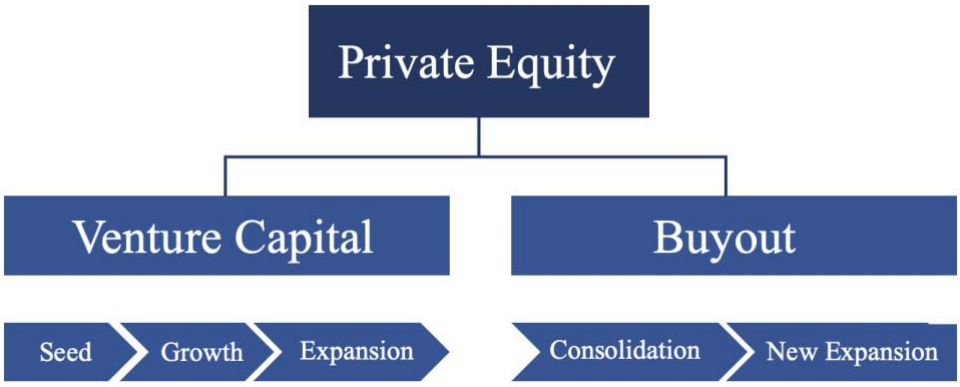
2.1 Private Equity

2.1.1 Equity Typologies

The investment of equity capital in private companies is known as PE. In a typical PE transaction, an investor purchases a stake in a private company with the hopes of increasing the value of that stake in the future (Snow, n.d.) Most of the investments made in the private equity market is done by PE funds, usually made up of institutional investors and the private equity fund managers (Gilligan & Wright, 2014). PE can in general be divided in to two categories, categorized of the life cycle and future needs of the companies that funds invest in.

Figure 1

Difference between Venture capital and Buyout (Demaria, 2013)



Venture capital

VC funds target small and medium-sized enterprises in start-up or growth phases, exhibiting high-risk/high-return potential. These companies often struggle to access capital markets due to factors such as lack of financial history, market relations, management skills, and tangible assets. VC funds serve as financial intermediaries, providing capital and specialized human capital to realize growth potential.

VCs focus on developing and expanding their portfolio companies, assuming risks associated with market entry and expansion. They offer expertise in commercializing technology and distributing services/products. VCs often join the board of directors, providing guidance and leveraging industry connections to recruit key employees (Metrick & Yasuda, 2011). They typically specialize in specific industries, adding value through supplier identification, customer relationship development, and production assistance.

Buyout

Buyouts occur in the later stages of a company's life cycle, typically targeting larger firms with strong earnings experiencing downturns due to poor management or market conditions. Unlike VC investments, buyouts involve PE firms acquiring a controlling stake, enabling decision-making power. Leveraged Buyouts (LBO) involve significant debt to finance acquisitions, reducing agency conflicts and aligning incentives (Grossman & Hart, 1980). Buyout funds invest in mature companies with stable cash flows, mitigating debt-related risks.

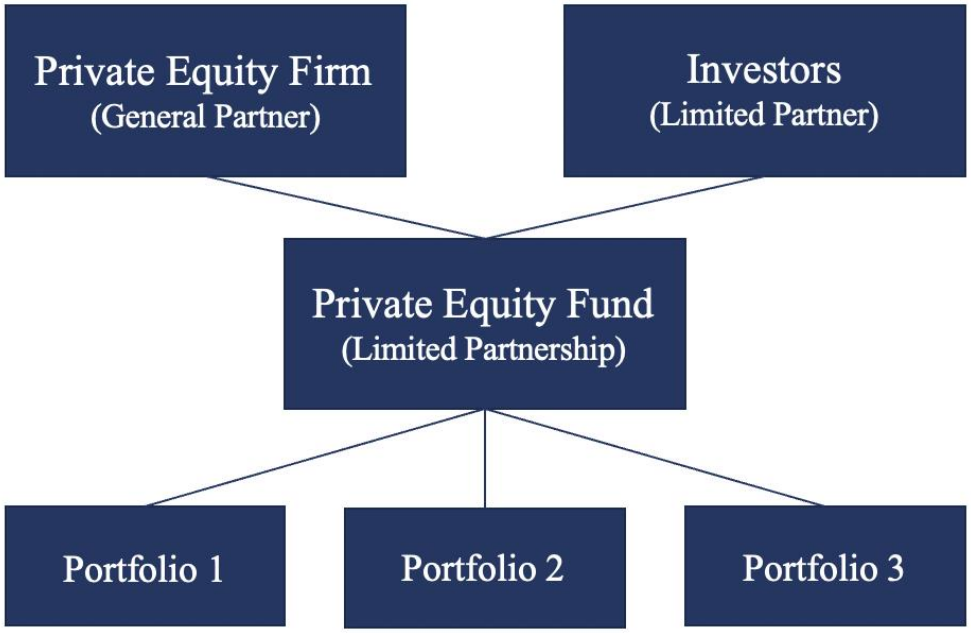
There are different forms of buyouts, such as Management Buyouts (MBO) and Institutional Buyouts (IBO). MBOs involve company management as the buyer, while IBOs involve external PE firms. Due to the difficulty in categorizing buyouts, this thesis uses the term PE for all later-stage buyouts.

Both buyout and VC funds operate outside public capital markets, limiting disclosure requirements. They acquire controlling stakes, actively manage companies, and charge management fees and carried interest. The concentration of ownership and use of debt reduces informational asymmetry risks. According to Kaplan and Strømberg (2009), 76% of investments are exited within 10 years and 51% within six years.

2.1.2 Private Equity fund´s structure

Figure 2

Private Equity Structure (Demaria, 2013)



PE firms are structured as limited partnerships, comprising General Partners (GPs) and Limited Partners (LPs). GPs manage daily operations and investment decisions, while LPs provide capital without direct involvement in daily operations, thus maintaining limited liability status. Typical LPs include pension funds, institutional investors, endowments, and wealthy individuals. GPs also contribute 1-2% of the capital as "skin in the game" (Demaria, 2013).

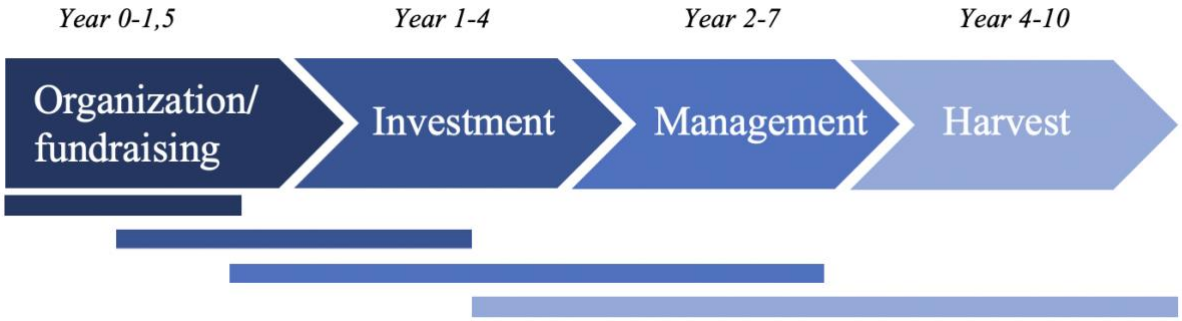
The Limited Partnership Agreement (LPA) outlines the contractual obligations between LPs and GPs, specifying the firm's lifetime, capital commitments, allocations and distributions, covenants, carried interest, management fees, and expense reimbursements (Cendrowski et al., 2012). Fund maturity usually ranges from 8 to 12 years, with over 90% of capital drawn within the first 3-4 years.

The LPA also details GP compensation, including management fees and carried interest. Management fees typically range from 1.25-3% per annum of committed capital, with an industry standard of 2%. Carried interest follows the "80/20" rule, wherein GPs receive 20% of the fund's profits as incentive for generating strong returns and aligning interests between LPs and GPs. The remaining 80% is distributed among LPs according to their capital commitment.

2.1.3 Timeline of a Private Equity fund

Figure 3

Stages of a Private Equity Fund (Cendrowski, Petro, Martin, & Wadecki, 2012)



Organization/fundraising

During the fundraising phase, PE funds attract investors and establish their investment strategy, often focusing on sectors like Information and Communication Technology (ICT) and HealthTech due to scalability and market reach, while others maintain broader strategies. PE funds, bound by regulations, rely on word-of-mouth promotion among LPs and emphasize maintaining long-term relationships with investors and gatekeepers. Gatekeepers connect GPs and LPs with similar investment criteria, while placement agents may also be utilized to attract investors. A PE fund's track record is crucial, as investors often reinvest in new funds upon closure.

Investment

In the deal-sourcing stage, GPs identify promising investments to generate cash flow for the fund. LPs pledge capital upon joining, but only a portion is withdrawn post-closing. GPs cautiously select deals with value-adding potential and request pledged capital from LPs upon projecting an investment closure. This process, known as capital calls, allows GPs to optimize internal rates of return, enhancing the private equity firm's reputation.

Management

Post-investment, the fund focuses on managing portfolio companies and maximizing profitability. This may involve active leadership, including management team replacement or attracting other funds for syndicated investments. Such collaborations with competitors enable GPs to access deals, share expertise, and benefit LPs.

This reciprocity in the PE industry also allows risk diversification and broadens the portfolio company's access to capital and human resources (Busenitz et al.,2017).

Harvest/divestment

The exit stage involves divesting from portfolio companies through secondary buyouts, IPOs, or trade sales. GPs aim to realize returns on assets, with some investments proving highly profitable and others not. Decisions on additional funding or liquidation are influenced by the investee's life cycle and the fund's finite lifetime. In the VC industry, failed ventures are discerned more quickly. The distinction between GPs lies in their ability to identify failures and reallocate capital to successful ventures.

2.1.4 What value does Private Equity and Venture Capital add?

Private Equity

Reduced agency costs

Jensen (1986) argues that takeovers by PE firms mitigate agency costs by imposing financial discipline through increased leverage, leading to efficient resource allocation, and improved corporate performance. Additionally, Jensen (1989) predicted the decline of public corporations and the rise of PE firms as more efficient alternatives. PE firms contribute value by reducing agency costs and enhancing corporate governance via concentrated ownership and effective monitoring, resulting in more streamlined organizations capable of generating value for stakeholders.

Transfer of wealth

Shleifer and Summers (1988) argue that hostile takeovers can lead to "breaches of trust," where new owners, including PE firms, may extract value from other stakeholders such as employees, creditors, and suppliers. This process can result in lower wages, decreased value of existing debt, and increased pressure on suppliers, which may lead to short-term gains for the new owners.

Informational and financing advantages

PE firms add value to portfolio companies by utilizing bank relationships to obtain improved financing terms. These relationships enable PE-sponsored firms to secure lower interest rates, larger loans, and favorable financing structures. The PE firms' financial restructuring expertise and monitoring capabilities bolster banks' confidence, resulting in better financing terms.

Through thorough assessment, PE firms get an informational advantage by utilizing their insights and skills. As a result of this informational advantage, they can purchase shares at a lower cost than if the information were readily accessible to all parties (Ivashina & Kovna, 2011).

Venture Capital

Sapienza (1992) examines the circumstances under which VC firms contribute value to their portfolio companies. Sapienza identifies several ways VC firms add value:

1. Expertise and guidance: VC firms often have substantial industry knowledge and experience, which can help guide startups through various challenges and support their strategic decision-making processes.
2. Networking and connections: VCs can provide valuable connections to potential partners, customers, suppliers, and other investors, enabling startups to grow their businesses and expand their network.
3. Financial resources: VC firms offer the necessary funding for startups to develop their products, scale their operations, and achieve their growth objectives.
4. Monitoring and oversight: VCs actively monitor the performance of their portfolio companies, provide feedback, and hold management accountable, ensuring that the startups remain focused on their goals and maintain a growth-oriented mindset.
5. Reputation enhancement: The backing of a reputable VC firm can enhance a startup's credibility and visibility in the market, making it easier to attract additional funding, talent, and customers.

2.1.5 Private equity in the Nordics

As the PE industry itself provides most of the information available, it is difficult to find unbiased information about private equity in the Nordic region. We have attempted to offer neutral statistics and information whenever possible. This part will cover the Nordic region and specify how it differs from the U.S.

Differences between Nordic and American PE

The disparities between the Nordic countries and the U.S. are examined in Spliid's (2013) article. Private equity research has primarily focused on conditions, theory, and data from the United States. Spliid´s study is also based on American theories and experiences.

Investment environment

When compared to other locations, such as the United States, the Nordic private equity sector has some distinguishing characteristics. For instance, the Nordic region's M&A market is one-third the size of the U.S. market in terms of GDP. In addition, as compared to GDP, the Nordic stock market is smaller and less deep in terms of market capitalization and trading volume. The legal systems differ as well; in the Nordic region, civil law is used, whereas common law is used in the United States. Because the legal systems have distinct standards, this discrepancy might have an influence on how private equity agreements are structured.

The Nordic region has considerably more rigid wage determination, with less of a relationship between productivity and income. This might influence how PE firms design management teams' compensation packages. Despite these distinctions, the Nordic private equity market has demonstrated outstanding growth and endurance, in part due to the region's long history of prosperous entrepreneurship and the market's focus on creating long-term connections and value.

Fundraising

Another difference between the Nordic and U.S. PE markets Spliid (2013) mentions is the source of funds raised. While the U.S. is large enough to rely on domestic investors, the smaller Nordic nations are reliant on international investors.

Historic perspective of PE in Norway

The Norwegian private equity market emerged in the early 1980s when large corporations such as Statoil (Equinor) began investing in private equity funds. Prior to this period, the sector was constrained by extensive government ownership, a small stock exchange, and late credit market deregulation compared to other Western countries. The government's credit distribution practices and the heavy leverage of traditional industries limited the growth of a robust private equity sector, which persisted until the early 1980s Moreover, few industries could support specialized asset management organizations, hindering the entry of international private equity operators (Mehrothra, Schaede, & Tørresen, 2011).

In the early 1990s, the Norwegian government established the Government Pension Fund of Norway, initially focusing on public equities and fixed-income securities (GPFG, 2021). The fund's mandate later expanded to include PE and alternative investments to strengthen capital markets, leading to the founding of Norske Venture AS in 1989 with 49% government ownership. The government sought to enhance equity in the Norwegian business sector by integrating resources from public, private, and commercial banking sectors with expertise (Mehrothra, Schaede, & Tørresen, 2011).

Market characteristics

Figure 4

Market characteristics of the Norwegian market

Total value of investment by phase in Norwegian companies (Norwegian Venture Capital Assosiation, 2022)

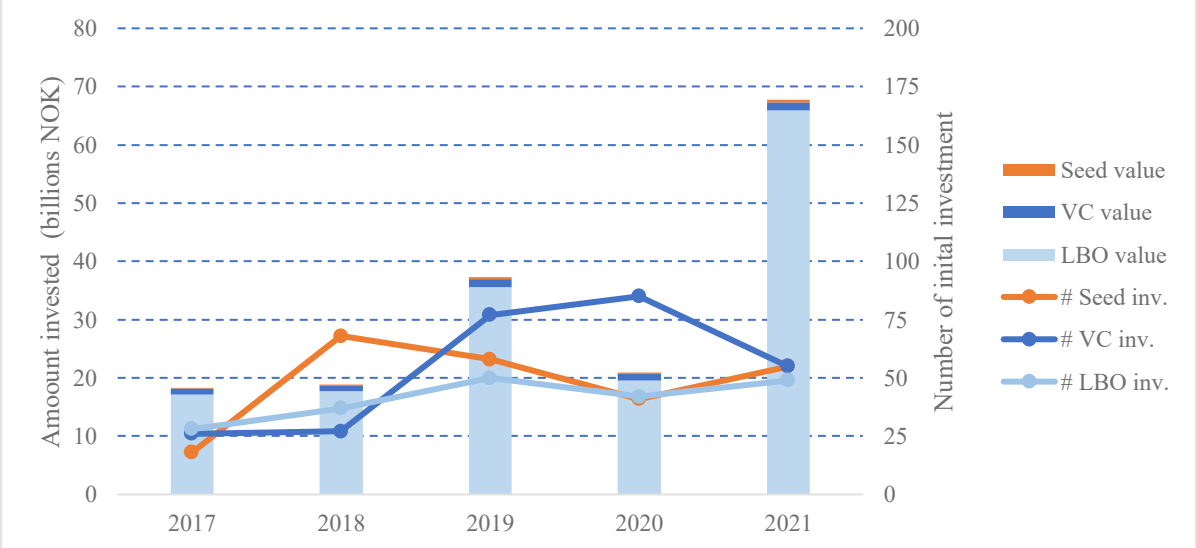


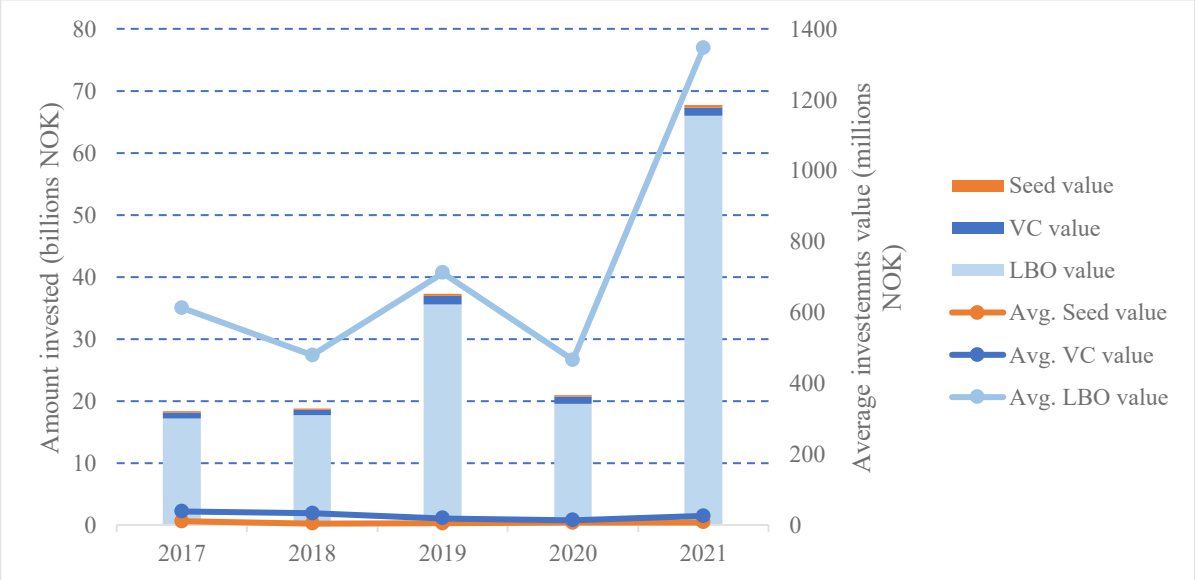
Figure 4 displays the total amount invested in Norwegian enterprises by both foreign and Norwegian PE firms and the buyout segment is heavily represented. Capital allocation to the seed segment is almost non-existent in the Norwegian PE-market; however, it reached its all-time high in 2021. The emerging picture makes sense when considering the dynamics of mature company takeovers through LBOs (PE), particularly when it comes to capital requirements. The total number of investments has increased throughout all phases, but mainly in seed and venture investments. The surge should be viewed in the context of the Covid-19 pandemic's easy access to cash, when interest rates dropped sharply, and it became easier to accumulate funds for investments. The convergence of investments in 2021 may be a result of interest rates turning around once more and the outlook for higher interest levels in the future, forcing investors to become more selective about their investments.

Each part of average deal value is broken down below. In this period, the number of initial investments in LBO´s has increased from 28 to 49 and the total amount invested is nearly tripled. The average deal size appears to have increased significantly over the past few years because of the increase in capital allocated to LBOs, while the number of deals has increased more moderately.

Figure 5

Capital Allocation in Norway

Total number of investments and mean initial investments by phase. (Norwegian Venture Capital Assosiation, 2022)



VC deals average values have fallen for consecutive years before moderately increasing in 2021 again. This pattern is mainly due to a huge increase in the number of deals from 2017 to 2020 before falling in 2021. The amount invested in VC deals overall have increased steadily in this period. Seed, on the other hand, has had little increase capital allocated, but the number of deals has increased significantly in this period. Resulting in a more even allocation of capital between investments.

Figure 6

Capital Allocation for VC- and Seed Investments

Total number of investments and mean initial investments by phase
(Norwegian Venture Capital Association, 2022).

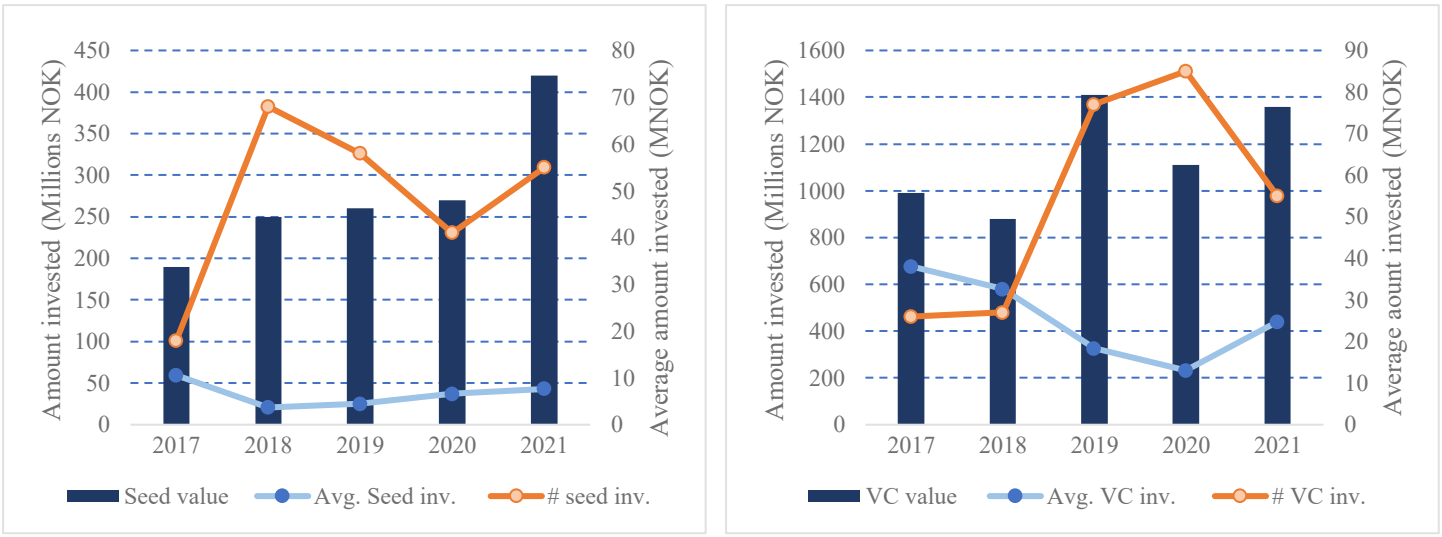


Figure 7

Top 5 PE Investments by Sector

The top 5 sectors based on numbers of listings within the sector. The data is gathered from the three most recent years available from NVCA, namely 2019, 2020, and 2021. The 5 most active sectors make out 80.93% of the total activity among all sectors. (Norwegian Venture Capital Assosiation, 2022)

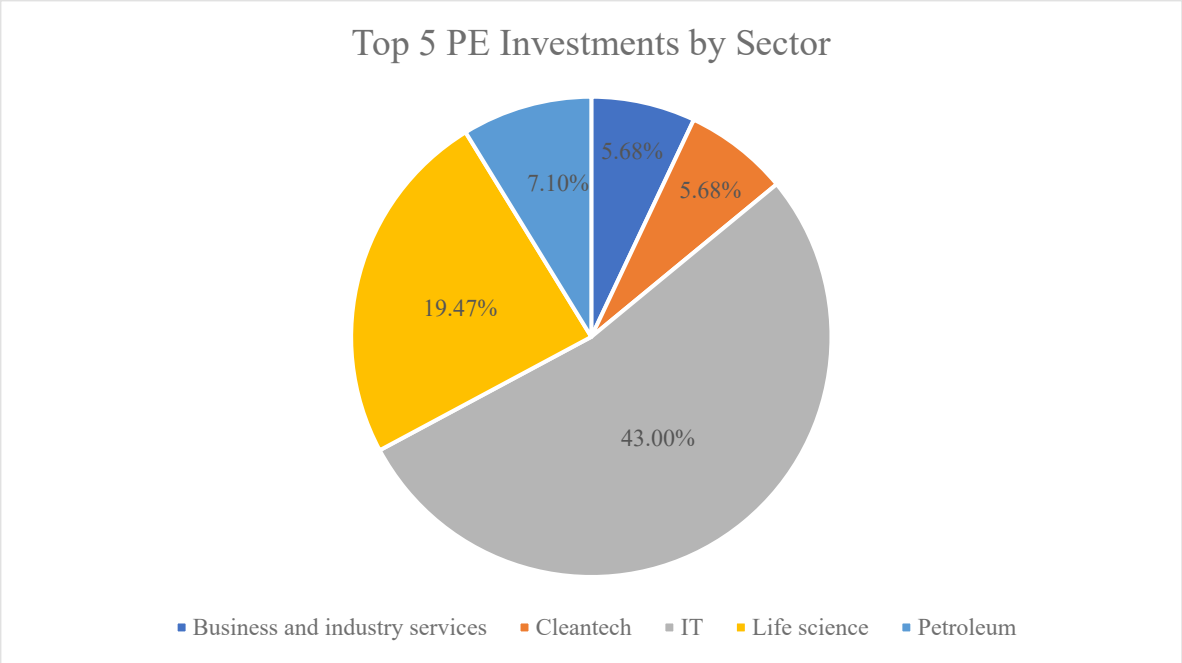


Figure 7 illustrates how private equity funds primarily invest in IT and life science, with cleantech, petroleum, and business and industry services also placing in the top 5. Because of Norway's exposure to natural resources, cleantech and petroleum hold significant positions in these industries.

This is coherent with the empirical evidence of Das, Jagannatha, and Sarin (2003), studying 23,208 unique companies from the U.S. market, and listing the five sectors with the most PE/VC engagement. Apart from the slant towards cleantech and petroleum, the allocation of investments is comparable to that in Norway, with over 60% going to IT, life science, and biotechnology.

2.1.6 Private Equity Exits

Because PE is a medium- to long-term investment, the fund's GP´s last objective is to harvest the value created by a divestment. The divestment is intended to transfer value from the PE fund to its investors (Folus & Boutron, 2015). Povaly (2006) mentions three traditional exit routes for PE investments: trade sales, secondary buyouts, and IPOs. This section will cover trade sales and secondary buyouts, while IPOs will be covered in section 3.

Trade sale

A trade sale is a way for the PE fund to realize their profits by selling to a strategic acquirer. The acquirer tends to be a non-PE firm and may even be the PE-sponsored company itself. Trade sales usually have the highest sales price of the exit strategies, as the buyer intends to hold the investment for a long time and expects a marked advantage and higher operating profits moving forward (Folus & Boutron, 2015). This may also be the reason why trade sales account for more than half of all global PE exits from 1995 to 2013 (Bain & Company, 2014). Trade sales also take place with a single buyer, making it more fluid and efficient process than the other exit routes. A disadvantage of a trade sale is that the company's management may fear that they are being replaced, making it tougher to complete the sale. Another disadvantage is that confidential information may be disclosed during negations (Folus & Boutron, 2015).

Secondary buyouts

A secondary buyout occurs when one sponsor sells a portfolio company to another sponsor. This transaction can be leveraged as well as unleveraged. A secondary buyout may be performed if the present sponsor feels that a larger sponsor will benefit the portfolio company. One advantage of selling to another PE firm is greater flexibility in the transaction arrangement, such as the selling firm holding a minority stake. A secondary sale is also a mechanism to resolve possible issues between the existing sponsor and the portfolio company's management (Folus & Boutron, 2015).

2.2 Initial Public Offerings

An Initial Public Offering (IPO) is the process of selling stock to the public for the first time (Berk & DeMarzo, 2020). This takes the form of a capital increase or a sale of currently held shares (EuroNext, 2022).

2.2.1 Overview of the Norwegian IPO market

If a company is considering going public in Norway, the three exchanges to choose from are Oslo Stock Exchange, EuroNext Growth and EuroNext Expand. These exchanges are separated by several factors to offer a suitable marketplace for companies in different situations. It is also not uncommon that companies change exchange after some time as well. The Norwegian IPO market is focused on sectors such as energy, shipping and, seafood (EuroNext, 2023b). The three sectors make up 56% of the listed stocks on Oslo Stock Exchange as of March 2023 (EuroNext, 2023c).

Regulated marketplaces

Oslo Stock Exchange

Oslo Stock Exchange (OSE) is the main stock exchange in Norway. It offers a marketplace to buy and sell stocks, bonds, and derivatives (EuroNext, 2023b). EuroNext recommends listing on the main market for larger, established companies. This is due to the higher level of listing and reporting requirements compared to EuroNext Growth and Expand (EuroNext, 2022).

EuroNext Growth

EuroNext Growth is another option to consider when going public in Norway. It was formerly known as Merkur Market before changing names in 2020 to fit within EuroNext's naming scheme. EuroNext Growth is best suited for small and mid-sized firms looking to finance their growth. The listing and reporting requirements are more lenient than those of the Oslo Stock Exchange, while still providing a liquid market (EuroNext, 2022).

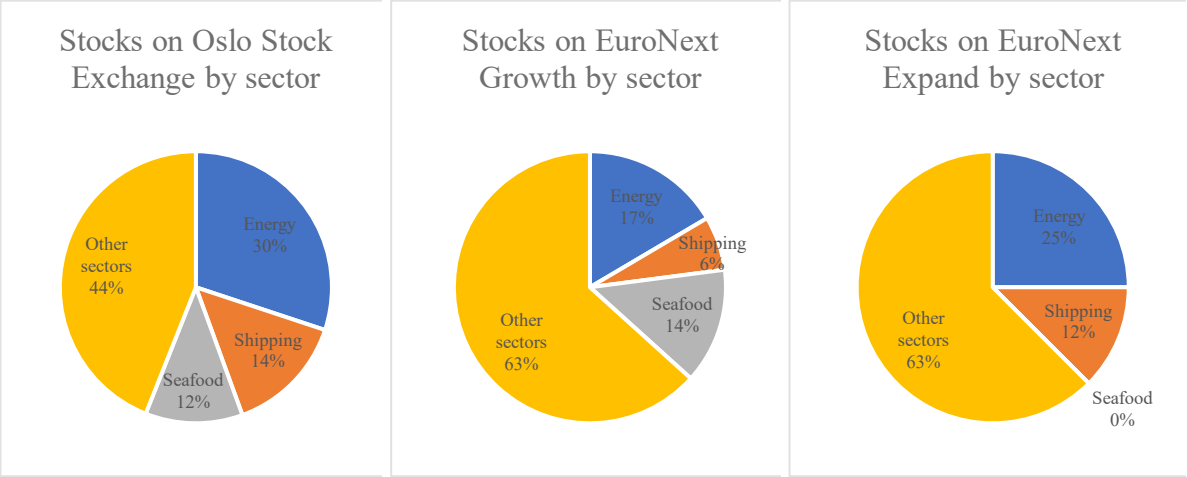
EuroNext Expand

EuroNext Expand is intended for smaller companies that lack the financial records and requirements for the other exchanges. It was known as Oslo Axess prior its name change in 2020. Expand is a way for smaller companies to enter an EU-regulated market, which increases the access to capital and acts as a quality stamp for the company (EuroNext, 2022).

Figure 8

Stocks on Norwegian Exchanges by Sector

The stocks listed on each of the three regulated marketplaces in Norway sorted by sector. Energy, shipping, and seafood are the highlighted sectors as they are three of the most central sectors in the Norwegian IPO market (EuroNext, 2023b).



2.2.2 The IPO process

When looking at how an IPO process works, it is beneficial to divide the pre-IPO process into two simultaneous timelines: documentation and marketing. Finally, there is a post-listing process to consider.

Documentation

The first step when going public in Norway is preparation. This process is initiated by a kick-off meeting before meeting the relevant market authorities. The next step is to submit a confidential prospectus to the local market regulators. The remaining time before the IPO is consumed by local regulators reviewing the documentation provided (EuroNext, 2023d).

Marketing

The first stage of the marketing phase is to initiate early-look meetings with targeted investors. Afterwards, the management presents the company to analysts, who will prepare a research report. This report will be the basis of discussions in the Pre-Deal Investor Education (PDIE). The final marketing step before the IPO is to perform the book building while management goes on a roadshow to meet potential investors (EuroNext, 2023d).

Post-listing

After the offering price has been set and the orders are allocated, the company is publicly listed and is ready to be traded on one of the authorized marketplaces available in Norway.

Evaluations and the application process

Prior to an IPO, an evaluation of the company is made to produce an offer document that discloses all relevant information. The offer document also describes the terms of the proposed transaction, such as the number of shares that will be issued. During the IPO process, due diligence sessions take place to ensure that the information in the offer document is disclosed appropriately (EuroNext, 2022).

The application process is initiated by submitting the first draft of the offer document to the financial regulator, which is the Financial Supervisory Authority of Norway. The regulator will then highlight all potential issues and make sure the issues are resolved before granting the final approval (EuroNext, 2022).

Financial reporting

When a company goes public, its financial reporting requirements change. The financial information must be more accurate and more detailed compared to private companies. As the company now has a broader pool of investors, it also must make sure that relevant information is distributed quickly and evenly to all investors. Financial reporting is a key element in a public company's growth and financial strategy, as investors perception of the company directly influences its price and value (EuroNext, 2022).

Underwriters

Underwriters are essential components to an IPO as they are responsible for managing the sales of the shares that are issued. Underwriters handle a variety of IPO-related tasks, including valuation, pricing, and risk management. In larger deals, there is typically a group of underwriters called a syndicate. The lead underwriter has the main responsibility for the deal, while other underwriters are brought in to assist. These other underwriters are called a syndicate (Berk & DeMarzo, 2020).

Valuation and book building

When determining the offer price of an IPO, the underwriters and the company work in tandem to work out a reasonable valuation. There are two main methods of valuation used: computing present value from future cash flows or looking at the value of comparable companies. Both methods are often used, but if the value differs significantly, the comparable valuation is regarded as higher. When deciding on an initial price range, the underwriters arrange a road show to find out what the market thinks of the valuation. A road show consists of senior managers and lead underwriters who visit large customers to reason their initial price range. Afterwards, the customers inform the underwriters how many shares they intend to purchase, and the underwriters adjust the offer price based on the amount of interest shown. This adjustment process is called book building (Berk & DeMarzo, 2020).

Pricing and risk management

The underwriters may receive payment through an underwriting spread, where the underwriters buy the shares of the issuing company for the final offering price minus the negotiated fee per share. The underwriters will then resell the shares at the offering price and receive their fee. This is called a firm commitment and exposes the underwriters to risk if they are not able to sell the shares at the offering price. Loughran and Ritter (2002) however find that only 9% of U.S. IPOs were down on the first day of trading between 1990 and 1998. The underwriters have several ways of reducing their risk exposure, namely by underpricing the shares or having an overallotment allocation (Berk & DeMarzo, 2020).

2.2.3 Advantages and disadvantages of going public

When a company is contemplating going public, there are several aspects of the IPO that must be considered to assess whether it is the right move for the company. Pagano, Panetta, and Zingales (1999) claims that the decision to go public is one of the least studied questions in corporate finance, while also being one of the most important questions. This is also apparent in corporate finance textbooks, where the subject rarely seems to be covered in-depth.

Liquidity and access to capital

One of the main benefits of going public is the increase in liquidity. This in turn enables the company's PE investors to diversify their investments. Another benefit of being a publicly traded company is the increased access to capital, both in the IPO and subsequent offerings, compared to raising funds as a private company (Berk & DeMarzo, 2020) While conventional wisdom states that going public is a natural stage in a company's growth, this is not necessarily the case. Pagano, Panetta, and Zingales (1999) argue that some large corporations, such as Bechtel, have decided to remain private companies for a long time.

Dispersion of ownership

While diversification is one of the largest advantages of an IPO, it also has one of the largest disadvantages. As investors diversify their investments, the dispersion of ownership increases. This ownership dilution makes it more difficult for the investors to monitor the company's management. This reduction in control can further reduce the price investors are willing to pay for the company (Berk & DeMarzo, 2020).

Monitoring and regulatory requirements

Due to several corporate scandals in the early 2000s, tougher regulations have been put in place to better protect investors. While this is an advantage for investors, it is both costly and time-consuming for publicly traded companies to implement. These regulations make public companies more thorough in their financial disclosure and promote greater accountability compared to private companies (Berk & DeMarzo, 2020).

2.2.4 IPO puzzles

Berk and DeMarzo (2020) mention four characteristics of IPOs that puzzle financial economists, namely high costs, cyclicality, underpricing, and poor long-run performance. In this section we will focus on the latter two, as these are relevant for our analysis.

Underpricing

Underpricing refers to the final offering price of the IPO being set too low, resulting in a positive first-day return. This seems to be the case in all markets, as the first-day average return for IPOs has been positive all over the world. This underpricing may be a way for the underwriters to mitigate risk, but it does come at a cost for the issuing company. Loughran and Ritter (2002) find that the average IPO leaves $9.1 million on the table, double the amount of direct fees paid to underwriters. The benefiting party in the case of an underpricing are the investors that purchased shares directly from the underwriters, and indirectly the underwriters as they please their customers (Berk & DeMarzo, 2020).

Ljunqvist (2004) presents several possible explanations as to why underpricing occurs in practically all markets.

Asymmetric Information

There are three central parties involved in an IPO transaction: the issuing firm, the underwriters, and the investors. Asymmetric information models within underpricing assume that one of these three parties is more informed than the others. One of these models is known as the Winner's Curse (Rock, 1986), which assumes that some investors are more informed than other investors, the issuing firm, or the underwriters. In this case, informed investors will only bid on IPOs they find well priced, while uninformed investors will invest in IPOs that are less likely to do well. This leads to a scenario where the uninformed investors will suffer from rationing when the IPO is attractive to informed investors, while they may receive all their shares in unattractive offerings. In the worst case, this can lead to uninformed investors obtaining negative average results due to unfavorable rationing (Ljunqvist, 2004).

Institutional Explanations

Ljunqvist (2004) brings up three institutional explanations of underpricing. The first one is based on a legal insurance hypothesis, where companies purposely sell their stocks at a lower price to avoid potential lawsuits from unhappy investors in the future. The second institutional explanation is based on price support. This is related to the underwriter's role in price stabilization, where the underwriters attempt to reduce potential price drops in the period following an IPO's launch. This will in turn reduce overpricing observations, influencing the mean of the average initial return positively.

Ownership and Control

An IPO often means a separation between ownership and control. This may result in an agency problem where managers maximize their control benefits rather than maximizing expected shareholder value. Brennan and Franks (1997) argue that underpricing is a way for managers to protect their benefits by strategically allocating shares, while Stoughton and Zechner (1998) believe that underpricing may be a way to minimize agency costs by encouraging monitoring (Ljungqvist, 2004).

Behavioral Explanations

As initial returns soared in the late 1990s, many researchers argued that the explanations presented above could fully explain this scale of underpricing. This has led to a focus on possible behavioral explanations for underpricing. One behavioral explanation of underpricing is that irrational investors bid up the price of an IPO beyond its actual value. Another explanation is that the issuing firm may have behavioral biases that result in them not pressuring the underwriters about reducing the underpricing (Ljungqvist, 2004)

Long-run underperformance

Long-term IPO performance has been the subject of extensive study, particularly since the early 1990s, when researchers shifted their focus from short-term underpricing. The long-term IPO performance literature reveals a general pattern of negative returns relative to appropriate benchmarks in the first three to five years after listing, known as the "long-term underperformance phenomenon."

Behaviorial Explanations

Behavioral theories attempt to explain seemingly irrational IPO investments by integrating behavioral and psychological aspects with classical finance theories. We will cover five different behavorial explanations for the long-run underperformance of IPOs.

Window of opportunity

The window of opportunity hypothesis suggests that when investors become overconfident about a company's value, share prices rise above their true market value. Sellers and advisors exploit this by issuing shares during boom times. According to Ritter (1991), shares issued during such periods are overvalued and should return to their fair value as more public information becomes available. The time frame of our sample, which covers the Norwegian market from 2010 to 2020, includes the Covid-19 pandemic, which caused a sharp decline in stock prices and consequently a bull run in the financial markets.

Divergence of opinion

Miller's divergence of opinion theory (1977) posits that IPOs' initial trading price is primarily determined by the most optimistic investors, causing share prices to temporarily rise above their true market value. The divergence effect between optimistic and pessimistic investors will decrease as more information about the company becomes available, resulting in a decline in share price.

Impresario theory

Impresario theory states that investment banks intentionally underprice the issue to create the appearance of excess demand. Overreaction and overoptimism caused by this initial excess demand push prices above their true market value, negatively affecting IPOs' long-term performance (Shiller, 1988; Kooli & Suret, 2004).

Earnings management

Earnings management occurs when management manipulates discretionary accounting accruals to inflate reported earnings before an IPO. These strategies can attract investors who may not fully adjust their valuations for misrepresented pre-IPO profitability, potentially increasing management compensation from IPO revenues. Over time, the effects of these manipulations become apparent, leading to negative long-term abnormal returns (Teoh, Welch, & Wong, 1998).

Prospect theory

Ma and Shen (2003) apply prospect theory to IPOs, arguing that the initial offering price serves as a reference point that influences investor decisions. Even if the stock performs well relative to the market, investors may be more likely to sell if the price falls below the IPO price. They examine the Shanghai Stock Exchange's initial public offerings (IPO) from 1996 to 2006 and discover that, over time, IPO equities underperform the market, possibly as a result of investor behavior changing in response to variations in the IPO price.

Other explanations

Some of the most well-known hypotheses about long-term IPO success are presented in this section, and some of them are related to or derived from research on IPO underpricing. The ideas are crucial to mention because they are traditional corporate finance theories.

Agency Costs and Asymmetric Information

The long-run underperformance of IPOs can be attributed to agency costs and asymmetric information. Agency costs arise from conflicts of interest between managers and shareholders, leading to suboptimal decision-making (Jensen & Meckling, 1976). Asymmetric information occurs when one party has more or better information than the other, creating an imbalance in the decision-making process. In the context of IPOs, the issuing firm's management typically possesses more information about the firm's prospects than potential investors. This information asymmetry can lead to adverse selection and moral hazard problems, potentially contributing to the long-term underperformance of IPOs (Myers & Majluf, 1984).

Signalling hypothesis

The signaling hypothesis suggests that high-quality firms intentionally underprice their IPOs to signal their quality and future prospects to potential investors (Spence, 1973; Welch, 1989). However, this underpricing can contribute to long-term underperformance, as subsequent market adjustments may lead to a correction in the stock price when more information becomes available and investor optimism declines (Rock, 1986; Ritter, 1991).

Uncertainty Hypothesis

According to the Uncertainty Hypothesis, the high amount of uncertainty surrounding new issues is a contributing factor to the IPOs' long-term underperformance (Booth & Chua, 1996). The market modifies its value of the firm as additional information becomes available over time, which might result in underperformance. Because new companies sometimes have little operational experience, it can be challenging for investors to appropriately appraise their potential (Beatty & Ritter, 1986). Thus, IPOs initially outperform, but as more details become available and uncertainty subsides, stock prices may fall, leading to long-term underperformance (Ritter, 1991).

3. Previous literature

3.1 Empirical findings on underpricing

The table below shows the average initial returns for IPOs in selected countries, with varying sample sized and time periods covered. The complete table of 55 countries can be found in Appendix 9.7.

Table 1
Equally weighted average initial returns for 11 countries
(Loughran, Ritter & Rydqvist (1994, updated 2023)

Country	Source	Sample Size	Time Period	Avg. Initial Return
Denmark	Jakobsen & Sorensen; Dealogic	190	1984-2021	7.6%
France	Husson & Jacquillat; Leleux & Muzyka; Paliard & Belletante; Derrien & Womack; Chahine; Ritter; Vismara; Dealogic	904	1983-2021	9.4%
Germany	Ljungqvist; Rocholl;Vismara; Dealogic	840	1978-2020	21.8%
Italy	Arosio, Giudici & Paleari; Cassia, Paleari & Redondi; Vismara; Dealogic	413	1985-2018	13.1%
Norway	Emilsen, Pedersen & Saettem; Liden; Dealogic; Fjesme	368	1984-2021	10.3%
Qatar	Dealogic	17	2003-2021	257.2%
Russia	Dealogic	64	1999-2013	3.3%
Spain	Ansotegui & Fabregat; Alvarez Otera; Dealogic	204	1986-2021	9.5%
Sweden	Rydqvist; Schuster; de Ridder	442	1980-2021	28.2%
United Kingdom	Dimson; Vismara; Levis; Vismara; Doukas & Hoque; Khurshed	5,309	1959-2020	15.7%
United States	Ibbotson, Sindelar & Ritter; Ritter	13,757	1960-2022	17.5%

Table 1 displays underpricing in all 11 countries, as does the remaining 44 countries included in Appendix 9.7. It is worth noting that the levels of underpricing vary greatly among the countries, with the lowest being Russia with 3.3% and the highest being Qatar with 257.2%. Loughran, Ritter, and Rydqvist (1994) argue that average initial returns tend to be higher when there is a greater degree of government interference and when the offering price is set early in the process. They also find that riskier firms tend to be more underpriced.

A literature review on underpricing by Katti and Phani (2016) found that there are several endogenous and exogenous factors that result in underpricing. The identified factors are either issue-specific, firm-specific, or economy-specific. The degree of the underpricing is explained by theories related to information asymmetry and signaling.

3.2 Empirical findings on long-run performance

Ritter (1991) investigated 1,526 U.S. IPOs from 1975 to 1984 and discovered substantial underperformance relative to comparable firms in size and industry three years post-offering. Ritter's findings suggest that occasional investor overconfidence in emerging growth companies' revenue prospects and the exploitation of investor sentiment by these companies contribute to underperformance.

Loughran (1993) examined a sample of 3,656 IPOs from 1967 to 1987, expanding on Ritter's (1991) data, and found long-run underperformance relative to an equally weighted NASDAQ index. Loughran reported a six-year holding period return (HPR) of 17.29% for IPOs and 76.23% for the NASDAQ index. Loughran and Ritter (1995) later included experienced equity offerings (SEOs) performance in a joint paper. Based on a sample of 4,753 U.S. companies that went public between 1970 and 1990, they determined that investors would need to spend 44% more in issuing firms to get the same wealth effect five years after the offering as in non-issuing firms.

There have also been findings made by other researchers that contradicts the underperformance of IPOs. According to both Gompers & Lerner (2003) and Jenkinson & Ljungqvist (2001), IPOs do not underperform compared to relevant benchmarks. Other findings suggests that IPOs even outperform the market in the long run, such as the ones made by Schuster (2003) and Da Rosa Silva et al. (2003). Additionally, Bessembinder & Zhang (2013) argue that the characteristics of the firm is more relevant for the performance than the actual IPO itself.

3.3 Distinctions between PE/VC and non-sponsored IPOs in previous literature

3.3.1 Underpricing

Buchner, Mohamed, and Wagner (2019) find significant differences between in both short- and long-term performance when investigating 851 U.S. IPOs from 2000 to 2014. A standout difference is that VC-sponsored firms are significantly more underpriced, seemingly due to a larger information asymmetry. Levis' (2011) findings challenge this, as he states that PE-sponsored IPOs are less underpriced than both VC- and non-sponsored (NS) IPOs. Levis (2011) further attributes the reduced underpricing to the market capitalization of PE firms, arguing that there is less risk with larger firms. Bergström, Nilsson, and Wahlberg's (2006) findings also indicate lower underpricing among PE-sponsored IPOs. This may be a result of a PE firm's high dependency on positive returns on their investments to maintain its funding. Underpricing can be considered a cost for the issuing company and the PE firm. The PE firm will therefore be more incentivized to minimize the underpricing. Furthermore, they find that NS IPOs are more likely to go public during hot issue markets than PE- and VC-sponsored IPOs, suggesting that NS IPOs more often attempt to time the market.

Hellmann and Puri (2002) suggest that VC-backed firms tend to professionalize earlier, notably with a switch to outside management, than non-VC-backed firms. This early professionalization might contribute to the observed higher underpricing of VC-backed firms due to the additional perceived value. Franzke (2004), on the other hand, underscores the importance of effective corporate governance, especially in PE-backed firms. This aspect helps mitigate information asymmetry, potentially explaining the lower underpricing seen among these firms. These studies, along with others, hint at the complexity of IPO performance dynamics, shaped by factors such as sponsorship type, firm size, market timing, and governance structures.

3.3.2 Long-run performance

Buchner, Mohamed, and Wagner (2019) also found that in the long run, PE-sponsored IPOs outperform VC-sponsored IPOs, but this difference is not significant using the Fama-French model. Levis (2011) also finds that the long-run performance of PE-sponsored IPOs is significantly better than that of VC or NS IPOs. Bergstrøm, Nilsson, and Wahlberg (2006) argue that PE IPOs on average outperform VC- and non-sponsored IPOs over all time horizons, with few exceptions. Brav and Gompers (1997) find that VC-sponsored firms outperform other firms using equally weighted returns, while value weighted returns reduce the underperformance of firms that are not VC-sponsored. Megginson and Weiss (1991) supplement these findings with a unique perspective. Their study suggests that VC investors often maintain their holdings post-IPO rather than cashing out immediately. This implies a lasting certification role, as these VCs continue to contribute in an active manner post-IPO, like PE backers. This behavior of VCs is a testament to their commitment to the firms they back, potentially contributing to their overall performance. However, it also adds complexity to the comparisons with PE-backed firms, as the dynamics of investor involvement may vary.

4. Hypotheses

Drawing from the different theories and studies discussed, there seems to be an inherent link between the underpricing extent and long-term performance. Holding other variables constant, one could logically anticipate that more underpricing might stimulate superior long-term returns, given the initial “discount”. Yet, several studies, such as Loughran and Ritter (1995), have illustrated that underpricing can coincide with weaker long-term performance, implying that an issue could be both underpriced and overvalued simultaneously. This perspective aligns with theories that contend companies exploit market sentiment to their advantage.

The matters of underpricing and long-run performance is multifaceted, influenced by a series of cyclical and iterative factors. In the subsequent sections, we'll delve into these influences and set forth our projections regarding PE/VC-backed IPOs. From there, we'll formulate our hypotheses based on these prognostications and detailed evaluations.

4.1 Underpricing

Sponsoring

For our analysis "Sponsoring" signifies the provision of operational, strategic, and financial expertise that a firm receives through the backing of a PE or VC fund. According to the winner's curse theory, IPOs must typically be underpriced, a strategy designed to mitigate the adverse selection dilemma faced by less informed investors.

The "certification effect" posits that PE/VC funds can minimize underpricing by vouching for the high quality of the firm on offer. Nonetheless, the existing research on this effect presents a mixed picture. Some studies, such as those by Megginson and Weiss (1991), Barry et al. (1990), report that pre-IPO PE involvement significantly limits underpricing. Conversely, research by Bergström, Nilsson, and Wahlberg (2006) contests the universality of the certification effect. Franzke (2004), Hellmann & Puri (2002) and Cao, Jiang & Ritter (2005) fails to uncover evidence to support the certification function of VC companies or well-known underwriters, which adds to this discussion.

Potential factors influencing underpricing in the context of PE/VC sponsorship can operate in two opposing directions. One argument posits that the degree of equity retained by the PE/VC funds during the IPO process might drive higher underpricing, since the financial benefits they derive from lowering underpricing are directly linked to the retention rate. This may lead to a misalignment between the incentives of the PE/VC funds and the issuers' objectives. An alternative perspective suggests that PE/VC funds can decrease underpricing by promoting long-term value creation through the introduction of effective management structures, strategic operations, enhanced monitoring, and the expansion of supplier and customer networks. Additionally, the reputation of PE/VC funds, which is often under increased public scrutiny during an IPO exit, is an important consideration.

The preponderance of empirical evidence leans towards lower underpricing in the presence of PE/VC involvement, which serve as a basis for our first hypothesis.

H_1: PE- and VC-sponsored firms display lower underpricing than non-sponsored firms

Market Capitalization and Risk

Higher market capitalization is consistently correlated with lower underpricing as well as better long-term success. Part of this is due to risk and visibility factors. Levis (2011) provides a comparison between PE and VC IPOs, and NS IPOs. His research indicates that PE IPOs exhibits less underpricing than VC IPOs and NS IPOs. He attributes this to factors including the size and maturity of these offerings. He places emphasis on the risk profile of larger offerings as a deterrent to underpricing. However, Megginson and Weiss (1991) present an alternative perspective, suggesting that the role of VCs limits underpricing, independent of market capitalization.

In the context of our study, we are assuming that market capitalization does have an impact on underpricing within our sample. We aim to quantify the risk associated with PE and VC-backed issuances, mainly to derive risk-adjusted returns but also to provide a basis for comparisons in underpricing.

H_2: Market capitalization affects underpricing.

H_3: The degree of underpricing is influenced by risk.

4.2 Long-run performance

The theories and studies discussed in section two and three highlights that an array of factors weighs in on the long-term performance of IPOs. The central hypothesis in our study seeks to pinpoint consistent and significant differences in this performance, conditional on the firms having benefited from PE/VC support. It's pertinent to mention that scholarly discourse offers diverse results concerning the impact of PE/VC backing on long-term performance. These disparities can be traced back to diverse factors like sample sizes, time frames, market specifics, methodologies, and adjustments for risk, all of which obstruct comprehensive generalizations. We will delve deeper into the most prevalent and universally acknowledged explanations for these documented differences.

Sponsoring

Brav and Gompers (1997) found that VC-backed IPOs outperformed NS IPOs using equal-weighted returns. Yet, value-weighting diminished this difference, suggesting long-term underperformance isn't unique to IPOs but is rather common among small firms. Conversely, Bergström, Nilsson and Wahlberg (2006) saw PE-backed IPOs outperform NS IPOs across all periods and methods. Levis (2011) noted similar abnormal performance in PE-backed IPOs but found no such trend for VC-backed ones.

This performance could be attributed to improved operational efficiencies, enhanced monitoring, and high debt levels during PE ownership, which could continue after going public (Jensen, 1986, 1989). Additionally, lock-up agreements and retained shares incentivize continued engagement, facilitating closer monitoring and reducing agency conflicts. Notably, while Megginson and Weiss (1991) suggest that VC's continued post-IPO involvement plays a certifying role, A steady decrease in ownership, starting with large initial returns that swiftly diminish over time, could result in shortsightedness, according to Bergström, Nilsson, and Wahlberg (2006).

Overall, evidence on long-term performance of PE/VC-backed firms is inconclusive. Studies including both VC and PE-backed firms generally show the latter outperforming, while focused VC studies yield mixed results.

H_4: PE- and VC-sponsored firms display better long-run performance than non-sponsored firms.

Market Capitalization

Market capitalization has been associated with a large decline in underperformance for both PE/VC and NS firms, as illustrated by Bergström, Nilsson, and Wahlberg (2006), Cao and Lerner (2009), and Levis (2011). The first study indicates larger PEs outperform smaller ones when returns are VW, albeit without considering different risk characteristics. They contend that changing market sentiment, particularly from overconfident retail investors who often prefer smaller IPOs, may have an impact on issue size's long-term performance. Institutional investors typically target larger IPOs, so the involvement of PE might help stabilize post-IPO prices against shifting sentiment. Cao and Lerner, while also observing better performance with VW returns, account for different risk characteristics.

On the other hand, Brav and Gompers (1997) blame smaller issuers, notably those with market capitalizations less than USD 50 million, for the underperformance of the NS sample. They found that when returns are equally weighted, VC-backed IPOs beat their non-VC counterparts, but this advantage vanishes when returns are value-weighted, indicating that smaller companies have lower returns.

H_5: Market capitalization affect long-run performance.

Risk

Numerous studies typically use industry peers, different benchmark modifications, or set CAPM $\beta = 1$ to correlate the risk exposure of PE/VC portfolios to the entire market. Some consider systematic risk differences, size, and the Fama and French 3-factor model's value effects. These studies reveal market betas significantly different from one. Given the PE/VC funds' operational structure, it's plausible they display higher than one market betas on the fund level, due to their high idiosyncratic risk. However, aggregate fund returns could show differing betas, thanks to diversification.

Cao & Lerner (2009) perform risk adjustments for PE-backed firms using both the Capital Asset Pricing Model (CAPM) and the Fama-French model, indicating significant betas ranging from 1.23 to 1.30. According to other studies, different investment stages and fund types have varying betas. It's important to bear in mind that betas exhibit significant time variation and inconsistency.

Our goal is to measure betas and alphas for our PE/VC and NS firm portfolios, using the Fama and French 3 factor model, liquidity, and momentum, and the CAPM to correctly adjust for total risk differences. This will determine the reliability and validity of long-run performance estimates.

H_6: PE- and VC-sponsored firms display different risk-adjusted returns than non-sponsored firms.

5. Methodology

5.1 Underpricing

5.1.1 Sponsoring

As a basis for our underpricing methodology, we use Ritter's (1991) definition of the term. The literature frequently uses this approach to evaluate the degree of underpricing, which is determined by the difference between the offer price and the closing price on the first trading day. We employ the first-day return methodology as used in Bergström, Nilsson, & Wahlberg (2006) to assess the underpricing of IPOs.

Our reasoning for calculating both the raw and simple returns of the stocks is based on the different properties of the calculations. One of the benefits of the raw returns is that they are logarithmic, which enables them to be additive since they include the compounding effect. Other benefits of logarithmic returns are their normality properties and their ability to smooth out noisy graphs. Simple returns are better suited for displaying differences between the samples, as they do not emphasize returns deviating from zero, like logarithmic returns do (Gundersen, 2022). The formula for the initial raw return is given by:

$$r_i = \ln\left(\frac{P_{i,1}}{P_{i,0}}\right)$$

Whereby $P_{i,1}$ is the first documented price that deviates from the offering price and $P_{i,0}$ is the offering price. The return of a benchmark index, the OSEBX, is then subtracted to correct the raw return for market fluctuations. For stock *i*, this abnormal benchmark adjusted return is defined as:

$$ar_i = r_i - r_b$$

Where ar_i stands for abnormal return, r_i for initial raw return, and r_b for benchmark return. When determining underpricing for the various portfolios, we segregate PE/VC and NS firms from one another before combining them in equally-weighted and value-weighted portfolios, as suggested by Bergström, Nilsson, & Wahlberg (2006).

We then assign weights to IPO stock returns in event time in accordance with their relative market capitalization after employing a time-varying GDP deflator to account for the influence of inflation on market capitalization weights.

$$AR_p{}^{EW} = \frac{1}{n_p}\sum_{i=1}^{n_p} ar_i$$

$AR_p{}^{EW}$ is the equally weighted abnormal return for portfolio p,

$$AR_p{}^{VW} = \sum_{i=1}^{n_p} w_i * ar_i$$

and $AR_p{}^{VW}$ is the value weighted abnormal return for portfolio p.

5.1.2 Regression

For firms with at least three years of post-IPO activity, we calculate equity betas and conduct a cross-sectional multiple regression analysis. Deflated market capitalization, equity betas, and a PE/VC dummy are used as independent variables in the regression, and raw firm-level, simple, benchmark-adjusted starting returns are used as the dependent variable.

$$Benchmark\ Adjusted\ Initial\ return = \beta_o + \beta_1(MCAP) + \beta_2(EBeta) + \beta_3(PE/VC) + u_t$$

We include three years of post-IPO returns for beta estimates to capture market sensitivity during a limited period after the IPO. When performing multiple regression analyses, it is critical to understand the assumptions behind the OLS model. These assumptions are listed in Appendix 9.1, and significant parts of each assumption are discussed in the analysis in the Bias section.

By value-weighting the benchmark-adjusted initial returns using GDP-deflated market capitalization values and aggregating them at the portfolio level, we consider the impact of size in addition to the regression model. By changing the proportional weights of each firm's market capitalization in relation to the base year of 2020, deflating corrects for inflation. Value-weighting initial returns highlights the importance of high capitalization firms.

5.2 Long-Run Performance

5.2.1 Sponsoring

To obtain the return data, we rely on the total return indexes provided by Refinitiv for the firms. The total indexes account for dividends, and it therefore gives a more complete picture of returns in a long-term analysis assuming reinvested dividends. Additionally, ignoring dividend payouts over longer investment horizons may lead to distortionary effects on the cross-section of returns (Brooks, 2008). We utilize the Total Return formula given by Berk & DeMarzo (2020) for delisted firms, as their total return is not supplied by Refinitiv.

$$RI_t = \frac{Div_t}{P_{t-1}} + \frac{P_t - P_{t-1}}{P_{t-1}}$$

The raw return is for stock i at time t is calculated by the following formula:

$$r_{i,t} = \ln\left(\frac{RI_t}{RI_{t-1}}\right)$$

Lastly, the simple return for stock i at time t is calculated by the following formula:

$$r_{i,t} = \left(\frac{RI_t - RI_{t-1}}{RI_{t-1}}\right)$$

When computing the long-run performance of the IPOs over a 36-month period, we ignore the initial period, as done by Ritter (1991). A central reason for ignoring the initial period when measuring long-run performance is the lack of availability of shares at offering price compared to market price. This is a consequence of the allocation procedure during the book building phase (Loughran & Ritter, 1995). We then use two measurement approaches based on Ritter (1991): (1) cumulative abnormal returns (CAR) and (2) buy-and-hold returns (BHR), with notations from Bergström, Nilsson, & Wahlberg (2006).

Cumulative Abnormal Returns

We calculate the CAR with monthly rebalancing and OSEBX as the benchmark. The monthly rebalancing is done so that the market cap of a delisted company is equally distributed among the remaining companies in the portfolio for the next month.

The monthly benchmark-adjusted returns are calculated using the following formula:

$$ar_{i,t} = r_{i,t} - r_{b,t}$$

Where $ar_{i,t}$ is the abnormal return for stock i at time t, $r_{i,t}$ is the monthly raw return and $r_{BM,t}$ is the monthly return of the benchmark. PE and VC-sponsored firms are separated from the non-sponsored firms, where the abnormal returns are calculated for each, and the results are then combined in a portfolio. By summing the abnormal returns of n IPOs launched during month t divided by the number of IPOs launched during the month, the abnormal return of the equally-weighted portfolio is determined by:

$$AR_{p,t}^{EW} = \frac{1}{n_p} \sum_{i=1}^{n_p} ar_{i,t}$$

$AR_{p,t}^{EW}$ stands for the equally-weighted accumulated return of portfolio p for each month t. The following formula determines the value-weighted portfolio:

$$AR_{p,t}^{VW} = \sum_{i=1}^{n_p} w_{i,t} * ar_{i,t}$$

Where $AR_{p,t}^{VW}$ is the value-weighted accumulated return of the portfolio p in month t, $w_{i,t}$ is the weight of stock i based on the deflated market capitalization of the portfolio in month t, as described in section 5.1.2. We use value-weighted in addition to the more traditional equally weighted portfolios to capture the effects of market capitalization size of firms. Size is of interest as Ritter (1991) states that smaller issues tend to performer poorer than larger issues that display underpricing. Then the CAR for each weighting method is the summation of each value of AR^{EW} and AR^{VW} respectively. A benefit of CAR is that it takes anomalous events that could affect the returns into account, as the methodology assumes that the effect of an event is immediately reflected in the price of assets (Ma, Pagán, & Chuc, 2009).

$$CAR_{t-T}^{EW/VW} = \sum_{t=1}^{T} AR_{t}^{EW/VW}$$

After obtaining the cumulative abnormal returns, we determine the t-statistic of the equally and value-weighted portfolio in month t. The calculations are based on Ritter (1991):

$$AR_{t-statistic}^{EW/VW} = AR_t^{EW/VW} * \frac{\sqrt{n_t}}{sd_t}$$

Where n_t is the number of observations made in month t and sd_t is the cross-sectional standard deviation of returns in month t. The t-statistic of the cumulative abnormal return of the equally and value weighted abnormal returns are found by:

$$CAR_{t-statisitc}^{EW/VW} = CAR_{1,t}^{EW/VW} * \frac{\sqrt{n_t}}{csd_t}$$

And csd_t is calculated by the following formula:

$$csd_t = [t * var + 2 * (t-1) * cov]^{\frac{1}{2}}$$

Where var is the average cross-sectional variance and the variable cov represents the autocovariance of the AR_t series at the first order.

Buy-and-Hold Returns

The second method we utilize when investigating the long-run performance of the IPOs is BHR. We calculate the BHR over periods of six months, a year, and three years because longer measurement intervals enable the identification of different performance patterns and the detection of abnormal performance. Additionally, the differing holding periods may allow us to see if it is profitable to hold the stock over a shorter time, relative to more traditional holding periods of three to five years (Bergström, Nilsson, & Wahlberg, 2006). BHR is useful because it considers "hot issue" markets, which are times when the typical underpricing of new issues is unusually high (Ibbotson & Jaffe, 1975).

The holding period returns, as used by Ritter (1991) are calculated as follows:

$$R_{p,T} = \prod_{t=1}^{T}(1 + r_{p,t})$$

Where $R_{p,T}$ is the BHR of the portfolio in the period T excluding the initial returns of each IPO, and $r_{p,t}$ is the return of each stock in the portfolio summated. The BHR measures the total return achieved by employing a buy-and-hold strategy from the start of the first month after flotation until the earliest of (i) 3 years of trading or (ii) the stocks delisting. To interpret the BHR, a Wealth Relatives measure is computed. The OSEBX is used as the basis of comparison, with the following formula:

$$WR_{p,T} = \frac{1 + R_{p.T}}{1 + R_{b,T}}$$

Where $R_{b,T}$ is the computed BHR for OSEBX in the analysis period. When interpreting the Wealth Relatives (WR), a value greater than 1 tells us that the IPOs outperform the benchmark, while a value of less than 1 signifies that the IPOs have underperformed.

5.2.2 Regressions

We employ the Fama-French (1992) multifactor model as the basis for our regression model. The multifactor model introduces additional explanatory factors, where HML (value) and SMB (size) have been found to be most significant (Womack & Zhang, 2003). We further include the liquidity factor of the Pástor-Stambaugh Model (2003) as it considers the risk premium that should occur due to illiquidity. We believe this factor may enhance the model's explanatory power because the Oslo Stock Exchange is described as a market where only a select few bonds are traded frequently, while the majority are traded infrequently (Ødegaard, 2017). We hereby assume that this statement is true for the remaining stock exchanges as well. We also consider the Carhart (1997) momentum factor, which is calculated as the average return on the two portfolios with high prior returns minus the average return on the two portfolios with low prior returns (Fama & French, 2023). The reasoning behind including a momentum factor is to control for winning stocks that perform well in the short term (MSCI, n.d)

The six assumptions that are used when performing an OLS regression on time series data can be found in Appendix 9.2. The portfolio is calculated monthly, where all issues in our analysis period prior to month t is included in the portfolio. We base our regression on the CAPM framework described in Fama & French (2004), with the formula for the equally weighted regression being the following:

$$r_{p,t}^{EW} - r_{f_t} = \alpha + \beta_p \left(r_{M,t} - r_{f_t}\right) + u_t$$

Here $r_{p,t}^{EW} - r_{f_t}$ is the equally weighted portfolio return for month t after subtracting the risk-free rate at month t, set equal to the 3-month NIBOR rate in Norway for month t. The 3-month NIBOR rate is the minimum alternative return on an investment as treasury securities is free of default risk (Fleming, 2000). As we compute returns monthly, it is beneficial to use a short term NIBOR rate. The intercept, frequently referred to as a risk-adjusted abnormal return, is denoted by α. The risk-free rate is subtracted from the slope of the regression line between the portfolio and the benchmark to obtain β_p. Lastly the error term is denoted by u_t. Similarly, the regression for the value weighted returns is shown in the following formula:

$$r_{p,t}^{VW} - r_{f_t} = \alpha + \beta_p \left(r_{M,t} - r_{f_t}\right) + u_t$$

We then run regressions for both the equally and value-weighted portfolios of the PE/VC and non-sponsored groupings with the following formulas:

$$\left(r_{PE/VC,t}^{EW} - r_{f_t}\right) - \left(r_{NS,t}^{EW} - r_{f_t}\right) = \alpha + \beta_p \left(r_{M,t} - r_{f_t}\right) + u_t$$

$$\left(r_{PE/VC,t}^{VW} - r_{f_t}\right) - \left(r_{NS,t}^{VW} - r_{f_t}\right) = \alpha + \beta_p \left(r_{M,t} - r_{f_t}\right) + u_t$$

Finally, we run multiple regressions using the Fama French multifactor model and the added liquidity and momentum factors:

$$r_{p,t}^{EW/VW} - r_{f_t} = \alpha + \beta_p \left(r_{M,t} - r_{f_t}\right) + s(SMB_t) + h(HML_t) + u_t$$

$$r_{p,t}^{EW/VW} - r_{f_t} = \alpha + \beta_p \left(r_{M,t} - r_{f_t}\right) + s(SMB_t) + h(HML_t) + [l(LIQ_t) + m(UMD_t)] + u_t$$

Where SMB is Small Minus Big, HML is High Minus Low, LIQ is Liduidity, and UMD is Up Minus Down (momentum). LIQ is the traded factor of the Pastor-Stambaugh Model (2003), which is an imperfect stand-in for the non-traded factor $\mathcal{L}_t$. LIQ is useful for evaluating alpha in a multifactor model with a role for liquidity risk (Pastor & Stambaugh, 2019).

These factors are determined by the following formulas:

$$SMB = \frac{1}{3}(Small\ Value + Small\ Neutral + Small\ Growth) - \frac{1}{3}(Big\ Value + Big\ Neutral + Big\ Growth)$$

$$HML = \frac{1}{2}(Small\ Value + Big\ Value) - \frac{1}{2}(Small\ Growth + Big\ Growth)$$

$$UMD = \frac{1}{2}(Small\ High + Big\ High) - \frac{1}{2}(Small\ Low + Big\ Low)$$

Lastly, the loading is represented by s, m, l, and m corresponding to each of the factors included in the regressions. m is the loading of UMD due to the error term u_t.

5.3 Potential errors and biases

5.3.1 Omitted Variable Bias

The OLS estimator will have an Omitted Variable Bias if an independent variable that affects the dependent variable is left out of the analysis (Stock & Watson, 2020). As we base our analysis on recognized researched from contributors such as Ritter (1991), we believe that this Bias is mitigated. We also base our risk analysis on extensions of the Fama-French model, including additional factors mentioned in Carhart (1997) and Pastór & Stambaugh (2003). By including additional independent variables, we believe the likelihood of Omitted Variable Bias is reduced.

5.3.2 Outliers

We trim our sample values to account for outliers by 2.5 percent of the top and bottom sample values. Truncated means are more trustworthy estimators than the complete sample mean because they are more resistant to extreme events. According to Bloch (1966), the trimmed mean provides a more reliable understanding of a sample distribution's central tendency. In our analysis we have adjusted the initial returns for the cross-sectional data, leaving the time-series returns unadjusted. Due to combination of high market capitalization and unpredictable stock returns, this may affect our estimations when using CAPM and multi-factor models to analyze portfolio returns. We do, however, consider a maximum of 36 months of returns to be enough for IPO-related developments.

5.3.3 Sampling and methodological errors

Our data collection involves multiple sources, which introduces the potential for sampling error. The population of IPOs, as determined by the "list-changes" documents of the Oslo Stock Exchange, is considered a reliable source. Although manual adjustments to this data might introduce some skewness, it is unlikely to significantly impact our study. We obtained PE/VC transaction information from Argentum. While the data appears trustworthy, it combines Argentum's observations and media coverage, which could introduce further bias. To address this problem, we have taken steps to manually confirm the existence of PE/VC funds prior to the IPO events using information that is readily available online.

In relation to underpricing, there is a portion of the complete sample firms' initial returns that we lack due to limited access to prospectuses. This missing data pertains to both PE/VC and non-sponsored firms' IPOs. There is a possibility that if the characteristics of the sample firms differ significantly from those of the overall population, it could lead to erroneous inferences. However, we believe it is unlikely that atypical businesses would have a higher likelihood of being included in our subsample.

5.3.4 Survivorship Bias

In our view, we decrease survivorship bias by using CARs and BHRs, which effectively expose differences in performance between IPO groups and consider the effect of bankruptcy. Negative returns brought on by failing firms compound over time and generate a terminal value that considers the impact of firms leaving the sample. Similarly, when we rebalance after an acquisition, we consider the premium that commonly occurs from said acquisitions.

5.3.5 New listing Bias

This bias relates to the impact of our sample firms' and the index's constituent firms' varying life cycles. By deducting benchmark returns from performance after the IPO, both the CAR and BHR methods calculate portfolio-level performance. Our findings may be skewed if the benchmark returns do not accurately reflect the returns of the portfolio firms. To produce risk-adjusted returns, we use multifactor models, where the extra factors operate as proxies for explanatory variables that are not included in the traditional CAPM model. By doing this, we distribute the explanatory power among characteristics like HML, SMB, LIQ, UMD and equity beta so minimizing the bias associated with utilizing only the index.

5.3.6 Rebalancing Bias

Rebalancing Bias occurs due to the different frequency of rebalancing employed in our portfolio and the benchmark. While we rebalance the portfolio monthly, the benchmark OSEBX is rebalanced semi-annually (Morningstar, 2023) and this may cause a bias in our analysis.

6. Analysis

6.1 Data Collection

Our sample encompasses IPOs from both the Oslo Stock Exchange (OSE) and Oslo Axess, excluding Sevan Drilling due to the unavailability of reliable return series. A complete list of PE/VC-sponsored firms included in our sample can be found in Appendix 9.7. Additionally, we have incorporated demergers as IPOs since they function as separate legal entities after divestment from the parent company, and the OSE lists them as individual IPOs. During our sample period, 130 companies went public, with 31 of them being actively managed by a Private Equity/Venture Capital (PE/VC) fund prior to listing. Our sample period includes periods with low oil prices and the recent Covid-19 pandemic, both of which appear to have influenced the distribution of IPO volumes across the years.

We identified PE/VC-sponsored IPOs through a step-by-step process. First, we gathered data on all IPOs from the OSE between January 1, 2010, and December 31, 2020, which we then matched with a list of PE/VC deals provided by Argentum.

Table 2
Distribution of IPOs
The table presents the distribution of PE/VC and NS IPOs on the OSE and Oslo Axess from 2010 to 2020. Panel A shows the absolute frequencies of each group, Panel B shows their frequencies relative to the total sample per year, and Panel C compares the annual frequencies between the two groups.

Panel A

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
PE/VC	3	0	0	3	3	2	0	6	1	3	10	31
NS	18	11	3	9	14	8	6	7	9	11	3	99
Total	21	11	3	12	17	10	6	13	10	14	13	130

Panel B

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
PE/VC	10%	0%	0%	10%	10%	6%	0%	19%	3%	10%	32%	100%
NS	18%	11%	3%	9%	14%	8%	6%	7%	9%	11%	3%	100%
Total	16%	8%	2%	9%	13%	8%	5%	10%	8%	11%	10%	100%

Panel C

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
PE/VC	14%	0%	0%	25%	18%	20%	0%	46%	10%	21%	77%	24%
NS	86%	100%	100%	75%	82%	80%	100%	54%	90%	79%	23%	76%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

6.2 Underpricing

6.2.1 Descriptive Statistics

We combine the adjusted returns in a portfolio after adjusting the returns for the benchmark return over the same period. The characteristics of the firm-level raw, benchmark-adjusted, basic starting returns distribution are also covered.

Due to the unreliability of the NS and PE/VC IPOs' offering prices, our dataset only includes the initial returns for 76 NS IPOs and 31 PE/VC-sponsored IPOs. To appropriately adjust value-weighted returns, we deflate the market capitalization of each company using a GDP-deflator that changes over time. We give symmetrically trimmed values in parenthesis, removing 2.5% of the top and bottom values to limit the effect of outliers.

Table 3

Descriptive statistics of underpricing

We define underpricing as the difference between the offering price and the first closing price that deviates from it, given no intermediate trading. We provide aggregate portfolio results, adjusting for the OSEBX return over the same period. This analysis covers initial returns for 76 NS IPOs and 31 PE/VC-backed IPOs, adjusting for inflation with a time-varying GDP-deflator. Extreme values in the top and bottom 2.5 percentiles are trimmed to manage outliers (shown in parentheses). We use simple returns to calculate raw underpricing due to their normalized values and intuitive results. However, for portfolio-level analysis, we use logarithmic returns to account for compounding while maintaining normality.

NS				
*Numbers in parenthesis are calculated applying symmetrically trimmed samples. cf. table info.	**Deflated Market Capitalization** Million NOK	**Raw Initial Returns Firm Level** Simple, Benchmark-adj.	**EW Initial Returns Portfolio Portfolio Level** Logarithmic, Benchmark-adj.	**VW Initial Returns Portfolio Level** Logarithmic, Benchmark-adj.
Minimum	37 (91)	-45.77% (-19.18%)	-61.61% (-21.59%)	-0.46% (-0.14%)
Maximum	61 000 (16 727)	110.43% (39.56%)	74.33% (35.58%)	2.62% (0.28%)
Median	1 948 (1 739)	0.04% (0.04%)	0.22% (0.22%)	0.00% (0.00%)
Mean	4 189 (3 000)	3.68% (2.62%)	2.20% (2.02%)	0.06% (0.02%)
Standard Deviation	8 594 (3 480)	19.56% (12.23%)	17.14% (11.53%)	0.34% (0.07%)
Skewness		2.47 (1.18)	0.60 (0.82)	6.40 (1.34)
Kurtosis		12.39 (2.00)	6.13 (1.43)	46.69 (3.35)
PE/VC				
	Deflated Market Capitalization Million NOK	**Raw Initial Returns Firm Level** Benchmark adjusted	**EW Initial Returns Portfolio Level Logarithmic.** Benchmark-adjusted	**VW Initial Returns Portfolio Level Logarithmic.** Benchmark adjusted
Minimum	138 (317)	-17.18% (-14.63%)	-19.54% (-17.49%)	-1.11% (-0.44%)
Maximum	17 301 (14 440)	52.97% (52.52%)	42.95% (42.03%)	7.76% (2.37%)
Median	1 213 (1 213)	-0.33% (-0.33%)	-0.24% (-0.24%)	0.00% (0.00%)
Mean	2 951 (2 699)	5.15% (4.27%)	3.71% (3.14%)	0.35% (0.14%)
Standard Deviation	4 280 (3 600)	16.52% (13.86%)	14.91% (13.92%)	1.47% (0.50%)
Skewness		1.46 (1.45)	0.89 (0.78)	4.57 (3.44)
Kurtosis		2.81 (3.92)	1.26 (1.60)	22.92 (14.86)

We found that while NS IPOs initially appear to be larger in size, the mean and standard deviation of both categories become quite similar after removing outliers. Underpricing ranges from -17.16% to 52.97% for PE/VC and -45.77% to 110.43% for NS IPOs in the raw, firm-level, benchmark-adjusted returns. These ranges significantly narrow and virtually align when the returns are trimmed, resulting in similar distributions.

When examining the raw data for NS IPOs, the distribution is normal, with a low Kurtosis score after adjusting for the extreme returns of IDEX ASA (110.43%) and Observe Medical (-45.77%). Interestingly, when trimming the PE/VC returns, the Kurtosis score increases. This is due to Vaccibody's underpricing being close to Exact Therapeutics, but only the latter firm

was trimmed. At the portfolio level, the equally-weighted (EW) returns are somewhat comparable even before trimming; however, NS exhibits more extreme values in their outliers, as evidenced by the Kurtosis score. The median does not change when trimming, which can be attributed to the relatively small sample with reliable data. It is worth noting that the median of PE/VC's returns is negative, indicating a high frequency of overpriced firms. The mean and standard deviation are similar before trimming but fall more after trimming due to more extreme outliers. Both groups are positively skewed, indicative of either a higher frequency of positive returns or more extreme values of underpricing.

PE/VC returns are concentrated around lower values and have a flatter distribution, with a greater number of higher values causing the asymmetry compared to NS. When examining the value-weighted (VW) portfolio, the most distinctive statistics are the large differences in extreme values before and after trimming. This is due to the large market capitalization weight of Adevinta, with a 20.45% weight and 12.79% underpricing. For PE, the discrepancy arises from Vaccibody, which has an 18.08% weight and underpricing of 42.95%.

6.2.2 Sponsoring

Table 4

Underpricing in event time

This table showcases the average underpricing of PE/VC-backed and NS IPOs, computed in event time using both equally- and value-weighted methods. Underpricing spans from the offering date to when the closing price first deviates from the offering price. Initial logarithmic raw returns are adjusted for OSEBX index returns during the same period. Extreme values in the top and bottom 2.5 percentiles are trimmed for accuracy, in parentheses. For detailed interpretation, refer to the previous table.

Portfolio Underpricing	PE/VC	NS
Equally Weighted	3.60% (3.16%)	2.20% (2.02%)
Value Weighted	10.68% (4.30%)	4.24% (2.09%)

Table 4 displays that PE/VC-sponsored IPOs tend to have a higher level of underpricing compared to NS IPOs in both equally weighted and value-weighted portfolios. However, when the extreme values are removed, the underpricing figures for both categories decrease, suggesting that a small number of outliers may be driving the observed differences in underpricing. When trimming the VW portfolios, both groups underpricing is more than halved. This is due to the large market capitalization of Adevinta and Vaccibody distorting the results. These findings may suggest that NS IPOs are more accurately priced than PE/VC IPOs, which is positive for the issuing firm.

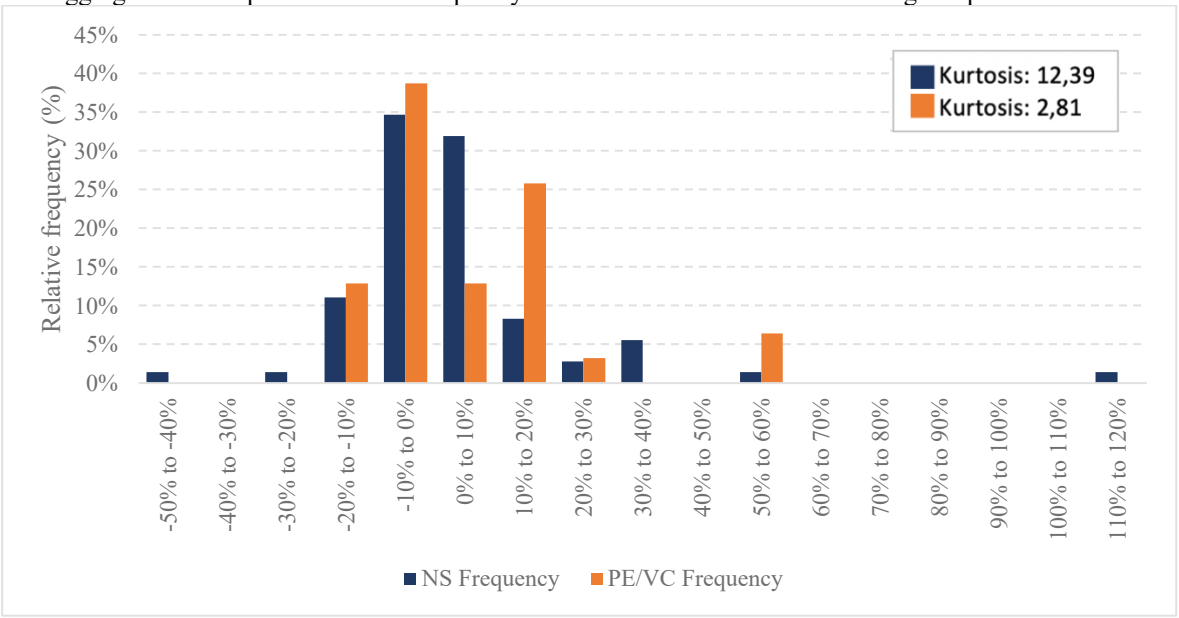
The t-test, on the other hand, does not show any statistically significant distinction in the mean for EW- or VW-portfolios, respectively. Furthermore, the small sample size may restrict the possibility of inference in our analysis.

Welch's t-test is used to compare mean differences across sample groups in both EW and VW portfolios. The t-statistic for EW portfolio is -0.45 and the p-value is 0.65. The t-statistic for VW portfolios is -1.09, and the p-value is 0.29. These p-values exceed the standard significance level of 0.05, indicating that there is no significant difference between the groups. When the trimmed samples are tested, the results show that the t-statistic for adjusted EW portfolios is -0.41 and the p-value is 0.68 The t-statistic for adjusted VW portfolios is -1.38 and the p-value is 0.18. The p-values for the trimmed samples, like the unadjusted results, are more than the 0.05 significance level. This implies that there is no statistically significant difference in averages between the sample groups for both the adjusted EW and VW portfolios.

Figure 9

Initial raw returns´ frequency and distribution

We illustrate frequency distributions of raw, benchmark-adjusted returns for PE/VC and NS firms. We chose simple over logarithmic returns to depict firm-level underpricing, reserving logarithmic returns for portfolio-level aggregations. We present relative frequency distributions to account for differing sample sizes.



A comparison of the portfolios made up of EW and VW logarithmic initial returns revealed no significant variations. However, the frequency distributions displayed above illustrate that the dataset of the raw, simple returns has notable differences.

Even though weighting helps to distinguish the contributions of large and small firms to the findings, the supplied distribution is purely descriptive and does not take size into account. Additionally, simple returns rather than logarithmic returns are used to calculate returns, providing a more realistic picture of the initial return distribution at the firm level. The raw initial returns dataset shows considerable differences and both NS and PE/VC display extreme observations.

Table 5

Underpricing in Calendar time

The average EW underpricing of PE/VC and NS IPOs is calculated in calendar time. We employ Ritter's (1991) definition of underpricing, which is defined as the initial return between the IPO day and the first day with a closing price that differs from the opening list price. The OSEBX return in the same calendar time is used to determine abnormal returns.

Year	PE/VC	N	NS	N	Diff.
2010	-15.31 %	3	6.54 %	14	-21.85 %
2011	-	0	6.72 %	8	-
2012	-	0	7.97 %	2	-
2013	-1.28 %	3	1.59 %	9	-2.87 %
2014	5.58 %	3	0.03 %	14	5.55 %
2015	1.22 %	2	0.89 %	6	0.33 %
2016	-	0	10.95 %	4	-
2017	0.54 %	6	-0.66 %	2	1.20 %
2018	-2.81 %	1	2.00 %	4	-4.81 %
2019	1.08 %	3	-5.47 %	8	6.55 %
2020	14.16 %	10	16.86 %	2	-2.70 %
Sum		**31**		**73**	

One thing to note from the results in Table 5 is that the PE/VC-sponsored company that went public in 2010, 2013 and 2018 was overpriced. Furthermore, the NS IPOs were underpriced, increasing the disparity, but considering the number of firms in these comparisons, it is difficult to explain why the discrepancies are so large. NS IPOs demonstrated constant underpricing from 2010 to 2016. 2010 is also the year where the difference between the two sponsoring groups were the largest, as PE/VC IPOs were overpriced by 15.31% on average, while NS IPOs were underpriced by 6.54% on average. The average underpricing of all PE/VC-sponsored firms was 0.40%, with a standard deviation of 8.26%. NS-sponsored firms displayed a larger average underpricing, with 4.31% and a similar standard deviation to PE/VC, equal to 6.24%.

6.2.3 Regression results

Table 6

Explanatory Factors of Underpricing

We perform a multiple regression on raw, benchmark-adjusted initial returns for PE/VC and NS IPOs, factoring in market cap (deflated using a GDP deflator), equity betas, and a PE/VC-backing dummy. Betas are calculated for companies active at least 36 months post-IPO, with a 60-month cap to assess IPO-related market sensitivity.

	(-1) **Robust OLS**
Market capitalization	0.00
	(0.00)
	t:1.613/ P>|t|: 0.111
Equity Beta	0.0187
	(0.022)
	t:0.704/ P>|t|: 0.483
PE/VC Dummy	0.007
	(0.053)
	t:0.013/ P>|t|: 0.990
Constant	0.0907
	(0.062)
	t:-1.468/ P>|t|: 0.146
N	80
Adj. R^2	0.029

Standard errors in parentheses, t- and p-values below.

* p<0.10,** p<0.05,*** p<0.01

Our findings demonstrate that the dummy coefficient has a marginal effect on the involvement of PE/VC firms in underpricing, but it is insignificant. Concurrently, the size impact has almost no effect on the dependent variable. Furthermore, according to Lewis (2011), the influence of risk has little effect on underpricing. The adjusted R^2 is not very high, at 0,029, making it difficult to use the model for predictions (Wooldridge, 2018). The F-test returns an F-value of 0,203, indicating that our explanatory factors are jointly insignificant. Including extra explanatory variables may be beneficial to avoid omitted variable bias. Our explanatory factors are collectively negligible, according to the F-test, indicating that we may have an omitted variables bias. Our analysis period includes low oil prices and the onset of the Covid-19 pandemic, which may skew our total IPO-sample in comparison to prior and upcoming IPOs.

In Appendix 9.3, we have included diagnostic plots that are useful to assess if the assumption of homoskedasticity is met. The plots show that the trimmed sample is more homoscedastic

than the original sample. Despite a few outliers, the structure of the error terms implies constant volatility. When we investigate the normality assumption of Appendix 9.1, we observe that IDEX ASA's abnormal initial returns invalidate the inference ability of our analysis, as shown in Appendix 9.3. When the IDEX ASA observation is removed, the residuals become more normally distributed. The estimated equity betas are still not significant, but they are getting closer when we regress using the updated sample. Significant equity betas would imply that less risky issues are underpriced.

After accounting for outliers, the p-values of the remaining explanatory variables all increase, except for market capitalization, which falls slightly. The adjusted PE/VC dummy's original positive coefficient, which indicated that it increases underpricing, is now negative. According to our adjusted data, which is consistent with the findings mentioned in section 3.3, risk appears to be the main factor causing underpricing.

6.3 Long-run performance

For calculating long-run performance of the firms in our dataset and the OSEBX index we use total return index (RI) supplied by Refinitiv, however for delisted companies they do not have the data. Thus, to retrieve data of delisted companies, manual data retrieval and calculations have been made. Since we want to calculate long-term performance disregarding initial returns, we compute the first total return index value in the first month following the IPO, in accordance with Ritter (1991).

6.3.1 Descriptive statistics

Table 7

Descriptive statistics of monthly abnormal returns

We use a simple monthly benchmark-adjusted return calculation based on the total return index level. This accounts for capital operations, like stock splits, and includes dividend reinvestment. Individual stock returns are compiled regardless of lifespan, while aggregated portfolio returns are calculated based on lifespan (up to 36 months) to isolate the "IPO-effect". Portfolios include firms that went public in the three years preceding each aggregated return month, which excludes longer-lived firms. If a company delists before the 36-month mark, we rebalance. Our dataset includes returns for 74 NB IPOs and 30 PE/VC-backed IPOs.

NS			
	Raw IPO Returns Firm Level Monthly Simple, Benchmark-adj.	**EW IPO returns Portfolio Level** Monthly Simple, Benchmark-adj.	**VW IPO Returns Portfolio Level** Monthly Simple, Benchmark-adj.
Minimum	-85.91%	-5.69%	-8.38%
Maximum	766.67%	12.54%	11.79%
Median	-1.38%	-0.82%	-0.75%
Mean	-0.58%	-0.57%	-0.60%
Standard Deviation	22.00%	2.85%	4.26%
Skewness	18.67	2.69	0.52
Kurtosis	238.76	12.61	0.57
PE/VC			
	Raw IPO Returns Firm Level Monthly Simple, Benchmark-adj.	**EW IPO returns Portfolio Level** Monthly Simple, Benchmark-adj.	**VW IPO Returns Portfolio Level** Monthly Simple, Benchmark-adj.
Minimum	-76.70%	-5.24%	-12.70%
Maximum	141.14%	4.20%	19.24%
Median	-1.27%	-0.03%	-0.76%
Mean	-0.25%	-0.15%	-0.31%
Standard Deviation	16.71%	2.64%	6.56%
Skewness	1.64	-0.15	0.49
Kurtosis	11.83	-0.86	1.06
OSEBX			
Minimum			-14.83%
Maximum			14.60%
Median			1.17 %
Mean			0.87 %
Standard Deviation			4.28 %
Skewness			-0.50
Kurtosis			1.96

To illustrate the differences of the raw dataset between the two groups we include IPOs' benchmark-adjusted firm-level returns. When calculating BHR, CAR and risk-adjusted returns however we use EW and VW portfolios.

In our analysis of IPO returns, we've found that the EW portfolio for NS firms, demonstrates lower mean and median returns, specifically -0.57% and -0.82% respectively, compared to their PE/VC-sponsored counterparts, which yield mean and median returns of -0.15% and -0.03%.We also observed that the NS EW portfolio tends to have a higher standard deviation compared to the PE/VC-sponsored IPO returns distribution, suggesting a greater occurrence of outliers. This is consistent with our analysis of raw firm-level returns, which confirms the presence of these outliers.

In terms of skewness, the NS EW portfolio shows positive skewness. This suggests that this distribution has a longer tail on the positive side, meaning that there's a higher probability of realizing large positive returns than large negative returns. Conversely, the PE/VC-sponsored IPOs exhibit a slight negative skew.

Drawing upon the lens of large market capitalization firms as represented by VW returns, we observe a slight shift in performance dynamics. The NS VW indicates a mean return of -0.60% and a median of -0.75%, suggesting small differences between small and large firms' initial returns. When considering PE/VC-sponsored firms, there is a notable decline in both median and mean returns as market capitalization increases. This implies that larger firms may not perform as well as their smaller counterparts. Notably, the return volatility for PE/VC-sponsored firms nearly doubles for larger firms and close to triples for NS firms. Comparatively, PE/VC-sponsored firms display close to 50% higher volatility than NS VW portfolios, highlighting the risk-return trade-off at play.

Between 2010 and 2023, the OSEBX demonstrates an average monthly return of 0.87%, outperforming both EW and VW NS and PE/VC-sponsored portfolios. This differential in returns underscores the importance of the market index as a benchmark for comparative analysis.

6.3.2 Sponsoring

Cumulative abnormal returns

Table 8

Cumulative abnormal returns in event time

CARs for both PE/VC and NB firms over varying periods, benchmarked against the OSEBX. The monthly abnormal return of each IPO is computed by subtracting the benchmark return from the raw return. We then aggregate these abnormal returns into equally- and value-weighted portfolios.

	NS			PE/VC		
Time period	**6m CAR**	**1y CAR**	**3y CAR**	**6m CAR**	**1y CAR**	**3y CAR**
Equally-weighted	-5.07 %	-17.35 %	-74.95 %	-13.98 %	-19.27 %	-57.76 %
Value-weighted	4.81 %	-2.31 %	-45.22 %	-6.38 %	11.28 %	-57.01 %

We observe notable distinctions in the CAR between NS and PE/VC sponsored firms over different time horizons. Upon initial analysis, the pattern of high initial returns followed by a rapid deterioration over time might suggest a degree of short-termism on the part of PE/VC firms, as proposed by Bergström, Nilsson, and Wahlberg (2006). This pattern is typically seen when these entities gradually reduce their ownership stake. However, it's important to bear in mind that certain companies debuted with an unusually high market capitalization, which could potentially skew the VW CAR results if these companies' trajectories deviate significantly from the average firm.

When examining the performance of large capitalization NS firms, it's clear that they have a substantial influence on the results we observe. However, for the largest PE/VC-sponsored IPOs, a compelling pattern emerges. These companies exhibit a performance profile that is analogous to small-capitalization firms over a three-year horizon. Intriguingly though, it's within the one-year timeframe that they make a significant contribution, driving the CAR into the positive territory for the PE/VC VW portfolio.

In the short-term view of 6 months, the EW portfolio for NS firms exhibits a negative return of -5.07%, which outperform the -13.98% return seen in the EW portfolio for PE/VC-sponsored firms. This suggests a more pronounced negative impact on the PE/VC-sponsored firms in the early months after the IPO. However, the performance dynamics change when we shift to VW returns; NS firms show a positive return of 4.81% in contrast to a negative return of -6.38% for PE/VC-sponsored firms. This suggests that, when accounting for firm size, larger NS firms tend to perform better in the short term.

Expanding our view to the 1-year mark, the downward trend continues for both NS and PE/VC firms in EW portfolios, with returns dropping to -17.35% and -19.27%, respectively. For VW portfolios, the NS firms dip slightly to -2.31% while PE/VC-sponsored firms turn positive with a return of 11.28%. This indicates that larger PE/VC-sponsored firms tend to improve their performance over the longer term.

Over the 3-year time horizon, all portfolios, irrespective of firm sponsorship or weighting method, demonstrate negative returns. The EW NS firms show the most significant drop at -74.95%, and the VW NS firms follow at -45.22%. The PE/VC-sponsored firms exhibit similar downward trends, with EW and VW portfolios yielding returns of -57.76% and -57.01%, respectively. This suggests that the risk associated with IPOs remains high over longer timeframes, regardless of firm size or sponsorship status.

While firm sponsorship and size may influence short-term performance post-IPO, the longer-term view suggests a generalized risk inherent to IPO investments. Further research might explore the factors driving these trends and possible strategies for mitigating the associated risks.

Table 9

Trimmed Cumulative Abnormal Returns in Event Time

CARs for both PE/VC and NS firms over several time horizons, benchmarked against the OSEBX. We use equal and value weighting with monthly rebalancing and apply symmetrical trimming to remove the extreme 5% from each portfolio.

	NS			PE/VC		
Time period	**6m CAR**	**1y CAR**	**3y CAR**	**6m CAR**	**1y CAR**	**3y CAR**
Equally-weighted	-4.72 %	-18.16 %	-70.18 %	-15.44 %	-19.92 %	-54.25 %
Value-weighted	-1.51 %	-12.71 %	-47.12 %	2.38 %	29.30 %	-48.00 %

When we examine IPO performance of the trimmed data, where we exclude the top and bottom 2.5% of data returns, we observe a slightly refined picture, but one that still underscores the key trends identified in the full sample.

In the trimmed sample, the VW NS portfolio continues to outperform all other portfolios across all periods, albeit with a reduced magnitude. The 3-year CAR for EW and VW NS firms improves slightly to -70.18% and -47.12%, less negative than in the full sample. An exception to this pattern is observed in the 6-month for the VW NS portfolio, which turn negative in the trimmed sample.

The PE/VC sponsored firms in the trimmed data, the trends largely mirror those in the full sample. However, a standout observation is the substantial increase in the 1-year CAR for VW PE/VC firms, which surges to 29.30%. This appears to be a clear demonstration of the impact of removing extreme outliers and suggests these firms' returns are more susceptible to market vagaries, a finding consistent with Ritter & Welch (2002). Nevertheless, this dataset is not without its own outliers. For instance, the outsized return of Kahoot in month 6, registering a 36.92% return with a weight of 21.34%, appears to distort the results somewhat.

This analysis, both in its full and trimmed forms, paints a nuanced picture of IPO performance over time, characterized by a general pattern of declining returns. It underscores the narrative that Ritter (2011) advocated for: Investors must approach IPOs with a thorough understanding of their inherent risks and rewards, and the recognition that high initial returns can often give way for more sobering long-term performance.

Figure 10
Cumulative Abnormal Returns in Event time

CARs are computed utilizing a method that employs monthly rebalancing and omits initial returns. These returns are then adjusted for the OSEBX return during the same period. Both equally and value-weighted measurements are employed over a maximum of 36 months. Market capitalization weights are adjusted to align with the base year of 2020, employing a GDP deflator to account for changes in general price levels over time. Both measures are accumulated separately in event time, disregarding the issue date, which allows us to calculate a CAR for each weighting method.

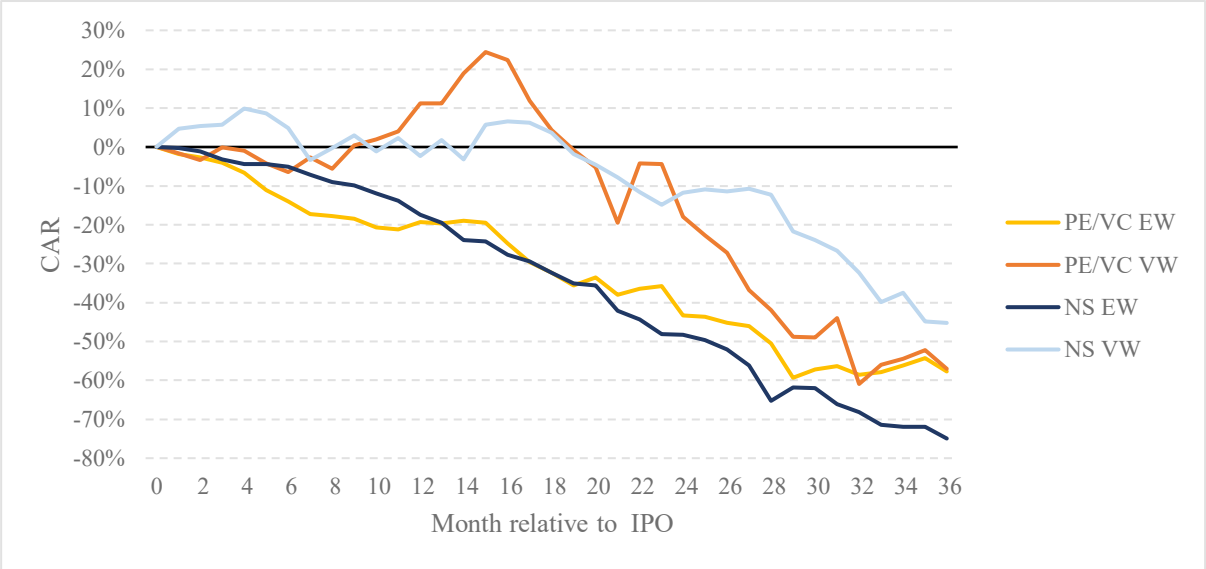
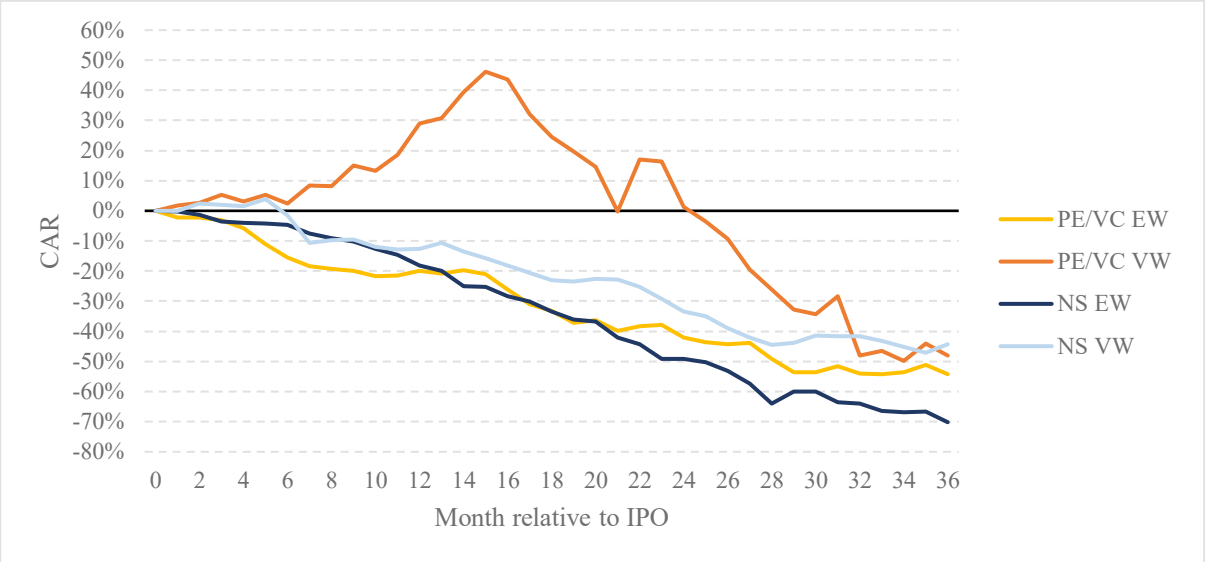


Figure 11
Trimmed Cumulative Abnormal Returns in Event time

CAR in event time for both PE/VC IPOs and non-sponsored IPO portfolios. This analysis applies symmetrical trimming, an approach that eliminates extreme CAR values. Specifically, it removes the top and bottom 2.5% of firms from each tail of the distribution. Subsequently, the returns of the remaining firms are recalculated, taking into consideration the new weights or proportions reflective of the adjusted dataset. Consequently, CARs are accumulated over an extended period of 36 months.



On average, we observe that Kahoot and Nykode Therapeutics carry a substantial market capitalization weight of 39.22% on average, over the course of 36 months, impacting the returns of the value-weighted PE/VC portfolio. In a similar manner, Adevinta and Gjensidige Forsikring, with their average sample period weight of 33.1% and 15.8% respectively, exert an influence on the NS portfolio, especially given the infrequent public offerings from comparably sized firms.

From Figure 10 and 11, we can observe that neither the CAR nor trimmed CAR portfolios outperform the benchmark index over the 36 months span relative to the IPO. The PE/VC VW portfolio and the NS VW portfolio manage to register positive returns and surpass the index between 9th and 18th months relative to IPO. Concurrent with the findings of Ritter (1991) and Loughran and Ritter (1995), our EW CAR calculations suggest underperformance relative to the VW CAR of NS IPOs. This underlines the superior performance of large capitalization firms compared to smaller, growth firms. However, the VW PE/VC CAR deviates from this narrative, showcasing a better performance in the short-term (9 to 18 months), but aligning with the long-term trend amongst large and small capitalization PE/VC-sponsored IPOs and NS firms.

Our findings also resonate somewhat with those of Bergström, Nilsson, and Wahlberg (2006) and Levis (2011) who found PE/VC IPOs to perform slightly better than other IPOs, for our dataset PE/VC perform better in the short term and NS VW perform better in the long term.

Our analysis suggests a performance differential based on the size of PE/VC firms. Specifically, we find that the EW portfolio, which favors smaller PE/VC entities, tend to underperform when compared to their larger counterparts, represented by the VW portfolio. However, for our data the results are ambiguous as PE/VC outperform only some periods, from month 23 to 36 NS perform better. Moreover, our results align with Brav and Gompers (1997), with the VW NS portfolio consistently being the best performer. To validate these observations statistically, we adopt the t-statistic methodology of Ritter (1991).

Table 10
t-tests: Equally Weighted Cumulative Abnormal Returns

The EW portfolio's abnormal return and the CAR, displayed as percentages, cover a 36-month post-IPO period (excluding initial returns). AR_t^{EW} is the weighted sum of benchmark-adjusted abnormal returns for each month t. The t-statistics for AR_t^{VW} in each month are determined by AR_t, the number of observations (n_t), and the standard deviation of adjusted returns (sd_t) for that month. The t-statistic for cumulative abnormal return ($CAR_{1,t}$) is calculated using the number of trading firms in each month (n_t) and the cross-sectional standard deviation (csd_t). The latter is derived from the event month, average cross-sectional variance, and first order autocovariance of the AR_t series over the 36-month span.

NS Equally-weighted						PE/VC Equally-weighted					
Month	N	AR_t %	t-stat	CAR_t%	t-stat	Month	N	Art %	t-stat	CAR_t%	t-stat
1	74	-0.27 %	-0.18	-0.27 %	-0.16	1	30	-1.83 %	-0.72	-1.83 %	-0.72
6	74	-0.63 %	-0.27	-5.07 %	-0.89	6	30	-3.32 %	-1.19	-13.98 %	-2.30
12	74	-3.62 %	-2.50	-17.35 %	-3.25	12	30	1.97 %	0.43	-19.27 %	-1.02
36	69	-3.05 %	-1.48	74.95 %	-6.85	36	20	-3.45 %	-1.57	-57.70 %	-3.55

NS Equally-weighted (trimmed)						PE/VC Equally-weighted (trimmed)					
Month	N	AR_t %	t-stat	CAR_t%	t-stat	Month	N	AR_t %	t-stat	CAR_t%	t-stat
1	70	-0.18 %	-0.11	-0.18 %	-0.15	1	28	-2.22 %	-0.81	-2.22 %	-0.79
6	70	-0.57 %	-0.24	-7.59 %	-0.79	6	28	-4.31 %	-2.36	-15.44 %	-4.32
12	70	-3.62 %	-2.42	-18.16 %	-3.33	12	28	1.57 %	0.32	-19.92 %	-0.99
36	65	-3.52 %	-1.66	-70.18 %	-6.25	36	18	-3.19 %	-1.32	-54.24 %	-3.07

Table 10, Figures 10 and 11 reveal a trend of sustained underperformance among NS and PE/VC-sponsored firms post-IPO relative to the OSEBX index, with negative returns intensifying over time (critical t-value=1.96).

This underperformance is statistically significant at various intervals (12th and 36th months for NS firms; 6th and 36th months for PE/VC firms), in both full and trimmed samples. The trimmed samples show this underperformance more starkly.

These findings align with Ritter's (1991) earlier observations of IPO firms underperforming the market in the long run. However, they contrast with studies like Brav and Gompers (1997) and Jain and Kini (1994), which recorded overperformance in VC-sponsored and some NS IPO firms. For our dataset both NS and PE/VC outperform the OSEBX for some time periods, both overtime display significant negative returns.

Table 11

t-tests: Value-Weighted Cumulative Abnormal Returns

The VW portfolio's abnormal return and the CAR, displayed as percentages, cover a 36-month post-IPO period, using the same methodology as in Table 10.

NS Value-Weighted						PE/VC Value-Weighted					
Month	N	ARt %	t-stat	CARt%	t-stat	Month	N	ARt %	t-stat	CARt%	t-stat
1	74	4.78 %	3.16	4.78 %	3.11	1	30	-1.63 %	-0.63	-1.63 %	-0.63
6	74	-3.82 %	-1.67	4.81 %	0.84	6	30	-2.17 %	-0.88	-6.38 %	-1.05
12	74	-4.69 %	-3.24	-2.31 %	-0.43	12	30	7.34 %	1.61	11.28 %	0.60
36	69	-0.33 %	-0.16	-45.22 %	-4.13	36	20	-4.82 %	-2.09	-57.01 %	-3.32

NS Value-Weighted (trimmed)						PE/VC Value-Weighted (trimmed)					
Month	N	ARt %	t-stat	CARt%	t-stat	Month	N	ARt %	t-stat	CARt%	t-stat
1	70	-0.01 %	-0.01	-0.01 %	-0.01	1	28	1.82 %	0.67	1.82 %	0.67
6	70	-5.44 %	1.00	-1.51 %	-0.25	6	28	-2.84 %	-1.52	2.38 %	0.66
12	70	0.06 %	0.05	-12.71 %	-2.26	12	28	10.44 %	2.20	29.03 %	1.49
36	65	2.79 %	1.64	-44.33 %	-3.77	36	18	-3.95 %	-1.63	-48.00 %	-2.72

Table 11 provides a view of the VW returns for NS and PE/VC-sponsored firms. NS firms´ CAR start with a positive return in the first month, but this becomes negative from the 12th month and continues to decline, indicating underperformance that is statistically significant at the 1st and 36th months. This underperformance is consistent with the findings of Ritter (1991) and Loughran and Ritter (1995). Conversely, PE/VC-sponsored firms begin with negative returns which deepen, except for a positive shift at the 12th month. The significant underperformance at the 36th month is notable. This observation resonates with the findings of Brav and Gompers (1997), who noted the underperformance of VC-sponsored IPOs in the long run.

For the trimmed samples, NS firms follow a similar pattern as before, experiencing a downturn from the 6th month with significant underperformance at the 12th and 36th months. PE/VC-sponsored firms exhibit a fluctuating pattern, with significant underperformance at the 36th month, which differs from the findings of Jain and Kini (1994) who observed NS IPO firms to outperform over a similar period.

Overall, these results indicate that both NS and PE/VC-sponsored firms generally underperform the relative to the OSEBX index over time after their IPOs.

Buy-and-Hold Returns

Table 12

Buy-and-Hold Returns and Wealth Relatives for non-sponsored firms

The table shows the BHR for NS IPOs in each year, and for the 6-month, 1-year and 3-year holding period. The associated WR for each holding period is also displayed.

		Buy-and-Hold Returns			Wealth Relatives		
Year	**N**	**6M**	**1Y**	**3Y**	**6M**	**1Y**	**3Y**
2010	11	13.07 %	15.69 %	-11.22 %	0.94	0.97	0.67
2011	7	-12.84 %	-8.39 %	78.81 %	0.92	0.95	1.28
2012	2	4.06 %	17.26 %	85.26 %	0.96	0.99	1.28
2013	8	39.15 %	-1.93 %	-21.68 %	1.27	0.84	0.63
2014	14	-0.05 %	-10.24 %	3.58 %	0.96	0.85	0.82
2015	6	14.36 %	16.46 %	6.17 %	1.18	1.18	0.78
2016	4	16.54 %	18.81 %	-6.88 %	1.13	1.06	0.71
2017	2	2.08 %	15.29 %	70.40 %	0.95	1.06	1.57
2018	4	11.06 %	11.53 %	23.39 %	1.01	1.06	0.96
2019	8	5.67 %	-13.67 %	47.75 %	1.07	0.92	1.07
2020	2	-5.84 %	16.40 %	-2.76 %	0.87	0.92	0.65

The BHR and WR for NS firms are shown in Table 12, organized by year. The returns vary depending on the year and return period, with a slight overweight of positive returns for each period. The WR measures if the IPOs perform better or worse than the benchmark, and the in most periods the IPOs underperforms the benchmark. There are no years where the IPOs outperforms the benchmark in all three periods. The results in 2013 sticks out, as there are a fair number of listings and they have a solid WR after 6 months, only to end up with the lowest WR after 3 years. The main reason for the positive WR after 6 months is Serodus' BHR of 359%, while it is –15% after three years. Additionally, several of the other firms listed in 2013 display large, negative returns after 3 years.

Most notably, Atlantic Petroleum display a return of -92%. These differing findings might indicate that long-term underperformance is a less obvious phenomenon than underpricing due to the general deviation in returns.

Table 13

Buy-and-Hold Returns and Wealth Relatives for PE/VC-sponsored firms

The table shows the BHR for PE/VC-sponsored IPOs in each year, and for the 6-month, 1-year and 3-year holding period. The associated WR for each holding period is also displayed. The blank spaces are due to there being no IPOs in 2011, 2012 and 2016.

		Buy-and-Hold Returns			Wealth Relatives		
Year	**N**	**6M**	**1Y**	**3Y**	**6M**	**1Y**	**3Y**
2010	3	-13.04 %	-28.75 %	-29.45 %	0.71	0.62	0.51
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	3	-9.13 %	-28.16 %	-58.63 %	0.82	0.58	0.33
2014	3	5.01 %	10.91 %	72.42 %	1.02	1.07	1.41
2015	2	-17.69 %	-29.15 %	-1.11 %	0.86	0.75	0.74
2016	-	-	-	-	-	-	-
2017	6	6.60 %	26.53 %	201.98 %	0.97	1.07	2.65
2018	1	-63.54 %	-27.08 %	140.76 %	0.34	0.69	2.99
2019	3	1.47 %	67.34 %	34.51 %	1.11	1.85	1.01
2020	9	15.83 %	41.60 %	-	0.98	1.13	-

There are fewer PE/VC-sponsored listings than NS with three years having zero listings. Additionally, we are unable to calculate the BHR and WR for the 3-year period for the listings in 2020, as they were all completed in the second half of the year. The listings made in 2017 and 2018 stick out in Table 13, as they display high WR after 3 years. In 2017 the high WR is driven by Crayon's 3-year BHR of 859%. poLight is the only listing in 2018, but it is worth noting that the WR after 6 months and 1 year were poor compared the 3-year WR. The results in this part may have less applicability due to the relatively small sample size, but they can still be helpful as a complement to the CAR.

6.3.3 Regression results

Table 14

Monthly risk-adjusted returns

We employ simple portfolio returns in our calculation of risk-adjusted returns, gathering data monthly over calendar time. We consolidate returns from IPO firms active within the three-year period preceding each observation month, applying both equally- and value-weighted measures. Firms active for more than three years post-IPO are omitted, allowing us to focus on IPO-related risk-adjusted returns. Panel A shows risk-adjusted returns for the Non-sponsored IPOs portfolio, using CAPM, Fama and French's three-factor model, and the extended model including liquidity and momentum as additional factors. All models were estimated across 159 monthly observations. Panel B mirrors this process for the PE/VC IPOs portfolio. We use equity betas to compute risk-adjusted returns, in accordance with Fama and French's (1992) assertion that size- and value-factors adequately account for leverage's role in stock returns. In our CAPM regressions, betas reflect leverage effects.

Panel A: NS IPO						
	$CAPM_{EW}$	**$CAPM_{VW}$**	**$FF3_{EW}$**	**$FF3_{VW}$**	**$FF5_{EW}$**	**$FF5_{VW}$**
α	-0.008	0.006	-0.005	0.007	-0.007	0.004
	(-0.003)	(0.005)	(0.003)	(0.005)	(0.005)	(0.007)
β	0.863***	-0.325***	0.833***	-0.331***	0.778***	-0.252**
	(0.074)	(0.110)	(0.065)	(0.106)	(0.074)	(0.112)
SMB			0.585***	0.487***	0.546***	0.487***
			(0.085)	(0.139)	(0.093)	(0.141)
HML			0.026	-0.110*	-0.005	-0.125
			(0.046)	(0.075)	(0.064)	(0.097)
LIQ					0.001	0.001
					(0.002)	(0.003)
UMD					-0.070	0.154*
					(0.056)	(0.085)
Months	159	159	159	159	159	159
Adj. R^2	0.461	0.153	0.582	0.229	0.586	0.256

PANEL B: PE/VC IPO						
	$CAPM_{EW}$	**$CAPM_{VW}$**	**$FF3_{EW}$**	**$FF3_{VW}$**	**$FF5_{EW}$**	**$FF5_{VW}$**
α	-0.002	0.000	-0.004	-0.001	0.009	0.013
	(0.006)	(0.007)	(0.006)	(0.007)	(0.011)	(0.010)
β	0.030	-0.076	0.052	-0.054	0.112	0.135
	(0.145)	(0.161)	(0.145)	(0.106)	(0.169)	(0.165)
SMB			-0.012	0.147	-0.069	0.142
			(0.190)	(0.210)	(0.213)	(0.208)
HML			-0.175*	-0.225**	-0.274*	-0.290**
			(0.103)	(0.114)	(0.147)	(0.144)
LIQ					-0.005	-0.005
					(0.004)	(0.004)
UMD					-0.266**	-0.156
					(0.129)	(0.126)
Months	159	159	159	159	159	159
Adj. R^2	0.052	0.153	0.192	0.184	0.283	0.226

PANEL C: PE/VC-NS IPO						
	$CAPM_{EW}$	**$CAPM_{VW}$**	**$FF3_{EW}$**	**$FF3_{VW}$**	**$FF5_{EW}$**	**$FF5_{VW}$**
α	0.006	-0.006	0.001	-0.009	0.016	0.005
	(0.008)	(0.008)	(0.008)	(0.009)	(0.013)	(0.008)
β	-0.833**	-0.415**	-0.781*	0.134	-0.666*	0.287
	(-0.275)	(0.187)	(0.277)	(0.188)	(0.297)	(0.224)
SMB			-0.499*	-0.110	-0.615*	-0.118
			(0.160)	(0.170)	(0.224)	(0.224)
HML			0.149	-0.144	-0.270	-0.168
			(0.126)	(0.134)	(0.173)	(0.170)
LIQ					-0.006	-0.004
					(0.005)	(0.005)
UMD					-0.366*	-0.276*
					(0.150)	(0.148)
Months	159	159	159	159	159	159
Adj. R^2	0.074	0.093	0.083	0.101	0.134	0.122

Standard errors in parentheses

* p <0.10,** p <0.05,*** p <0.01

For our Fama-French (1992) multifactor analysis, we've utilized the calculations provided by Bernt Arne Ødegaard (2023) to ascertain the parameters. We chose an OSESX and OBX-based long-short portfolio configuration specifically for the Small Minus Big (SMB) factor.

This methodology is used to evaluate the active management of the Norwegian government pension fund in a manner comparable to MSCI. The OBX is made up of the 25 OSEBX equities with the highest trading volume over the previous six months, whereas the OSESX is a total return index made up of the lowest 10% capitalized stocks (EuroNext, 2023a).

We've chosen to use local Fama-French calculations as it has been shown that local factors are more successful at explaining time-series variations in stock returns than their global counterparts (Fama & French, 1998; Griffin, 2002). To validate our inference, we carry out tests for autocorrelation (see Appendix 9.5) and apply the Newey-West procedure for correcting standard errors for heteroskedasticity and autocorrelation, in line with the methods proposed by Newey & West (1987).

We further delve into Cochrane-Orcutt and Prais-Winsten transformations on our regression models to check if the estimates we get are markedly different from the estimates given by OLS models. Our observations do not show any of these deviations, and the Dickey-Fuller tests confirm that our data series does not include a unit root (see Appendix 9.4). Furthermore, trends do not appear to affect our data-series, as seen by the insignificance of the coefficients produced by the linear trends that were applied.

Panel A: Non-Sponsored IPOs

Interpreting these model outcomes, we find that, in terms of alpha (representing abnormal returns), the EW portfolio slightly underperforms relative to the market average and VW portfolio slightly overperforms, after accounting for risk factors. The annualized alphas produced by the models we use range from -10.8% to 8.7%. It's crucial to note, however, that the alphas are statistically insignificant across all models, as shown by the corresponding standard errors.

The beta coefficient, which indicates the sensitivity of the IPO portfolio's returns to the overall market returns, we find a distinctly positive beta for the EW portfolio. This suggests that returns of this portfolio tend to move in the same direction as the market. Conversely, the VW portfolio exhibits significant negative beta values, indicating an inverse relationship with the market performance.

Looking at the SMB factor, which signifies the differential returns of smaller firms over larger firms, we see positive and significant values across all models. This is indicative of the IPO portfolio's tendency to outperform in periods when smaller firms fare better than their larger counterparts. Regarding the HML factor, which signifies the differential returns of value stocks over growth stocks, we find negative and significant values at 10% for the VW portfolio. This implies that the IPO portfolio tends to yield higher returns during periods when growth stocks are outperforming value stocks.

For the FF5 models, two additional factors, LIQ and UMD, have been considered. The LIQ coefficients are statistically insignificant, suggesting that liquidity does not significantly influence the IPO portfolio's performance. Nonetheless, the UMD factor in the VW portfolio points towards a role for momentum, as suggested by its significant coefficient at 10% for the FF5VW.

Figure 12
NS IPOs Equally Weighted Time-Varying Alpha Estimates

The figure displays the progression of alpha estimates for NS IPOs over time, utilizing the expanded Fama and French model on returns from an equally-weighted portfolio. We execute this estimation process employing a moving window analysis, incorporating 24 months' worth of observations at a time. The plotted 95% confidence bands, which signify two standard deviations, allow us to discern periods in the historical data when the risk-adjusted returns were statistically distinguishable from zero, based on a 5% level of significance.

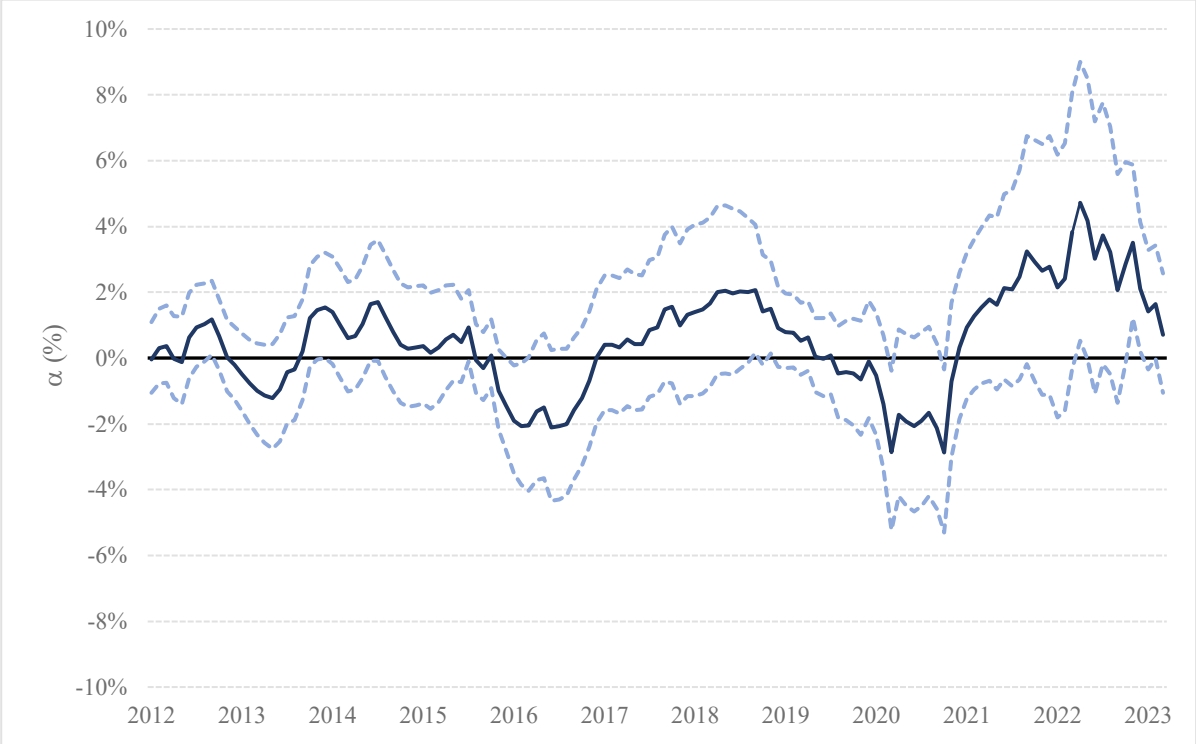
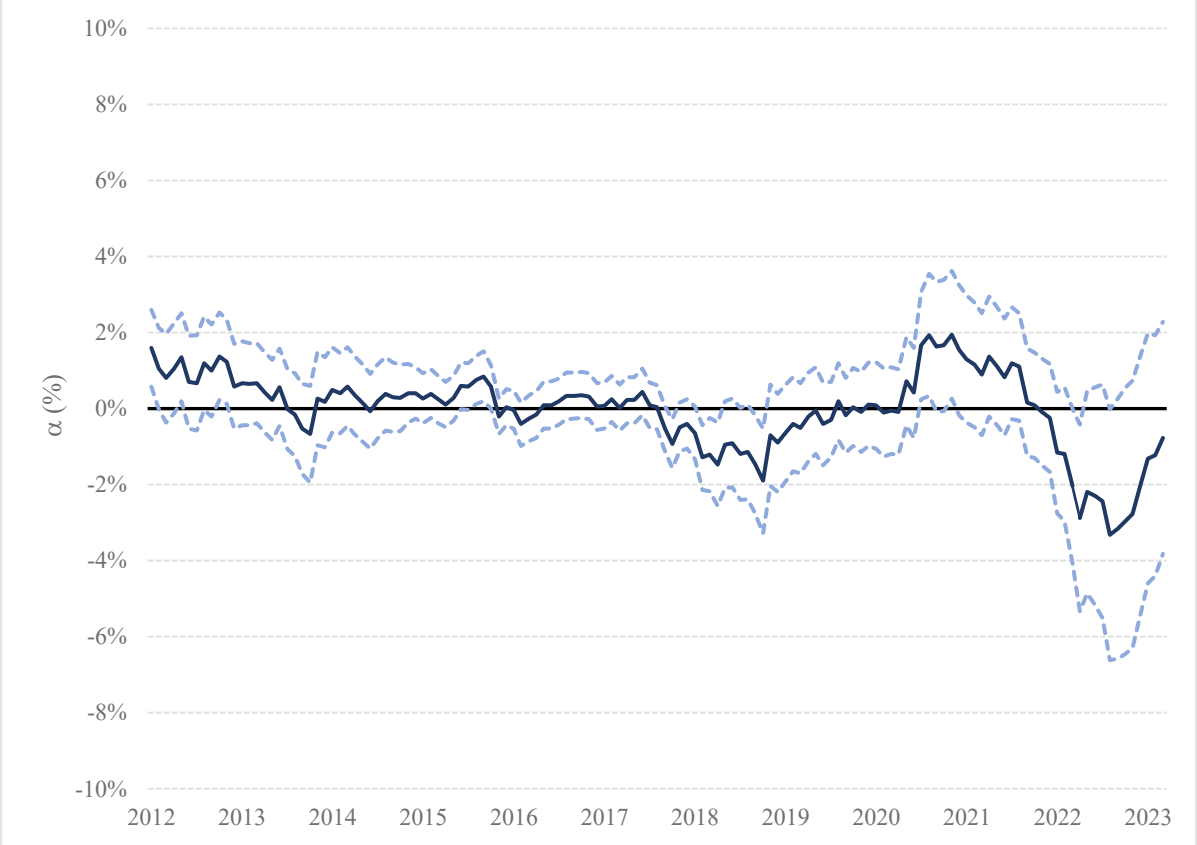


Figure 13

NS IPOs Value Weighted Time-Varying Alpha Estimates

The figure displays the progression of alpha estimates for NS IPOs over time, utilizing the expanded Fama and French model on returns from a value-weighted portfolio. We execute this estimation process employing a moving window analysis, incorporating 24 months' worth of observations at a time. The plotted 95% confidence bands, which signify two standard deviations, allow us to discern periods in the historical data when the risk-adjusted returns were statistically distinguishable from zero, based on a 5% level of significance.



Panel B: PE/VC IPOs

In Panel B, all models display statistically insignificant alphas. This implies that PE/VC IPOs do not consistently underperform or outperform the market when adjusted for risk factors. Annualized alpha estimates for PE/VC IPOs range from -4.9% to 16.8%. Statistically speaking, the range is not significant, although it is wider than for the NS sample.

Regarding market sensitivity or beta, each model reveals relatively small and statistically insignificant values, signifying that PE/VC IPOs returns does not exhibit a strong response to market movements. Models with negative betas, specifically those VW suggest a minor inverse correlation with the market, though the small magnitude and lack of statistical significance render these correlations weak.

When we observe the SMB factor, we notice statistically insignificant coefficients. This implies that the relative performance between small-cap and large-cap stocks doesn't have a strong bearing on the PE/VC portfolio's returns. Meanwhile, all models containing the HML factor exhibit negative and significant coefficients at 5% and 10%, indicating the portfolio returns tend to be superior during periods when growth stocks perform better than value stocks.

When considering the LIQ factor, we see small and statistically insignificant coefficients, signifying that liquidity doesn't majorly influence portfolio returns. The UMD coefficient is significant at 5% for $FF5_{EW}$ indicating that this portfolio performs better in times when past losers outperform past winners, the portfolio has a negative exposure to momentum.

The adjusted R^2 value values of these models are relatively low, suggesting these models do not adequately explain the variation in portfolio returns. The best adjusted R^2 value we observe is 0.283 for the $FF5_{EW}$ model, indicating that the inclusion of additional factors, such as liquidity and momentum alongside market, size, and value risk factors, provides the most effective fit among these models. However, even this model leaves a substantial part of the portfolio's returns unexplained.

Figure 14

PE/VC IPOs Equally Weighted Time-Varying Alpha Estimates

The figure displays the progression of alpha estimates for PE/VC IPOs over time, utilizing the expanded Fama and French model on returns from an equally-weighted portfolio. We execute this estimation process employing a moving window analysis, incorporating 24 months' worth of observations at a time. The plotted 95% confidence bands, which signify two standard deviations, allow us to discern periods in the historical data when the risk-adjusted returns were statistically distinguishable from zero, based on a 5% level of significance.

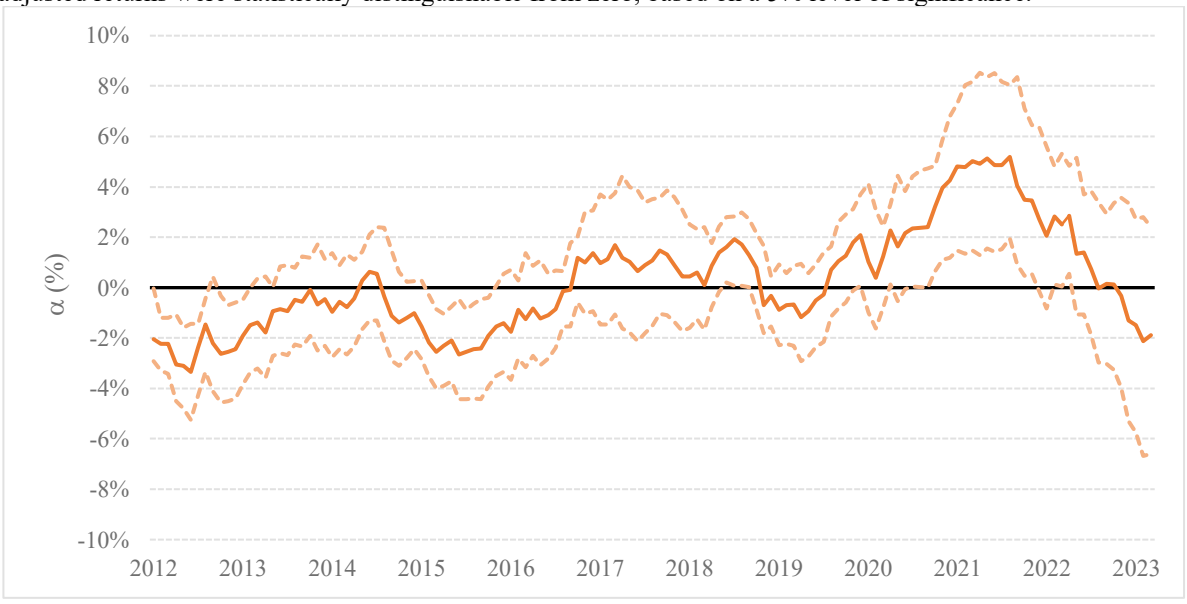
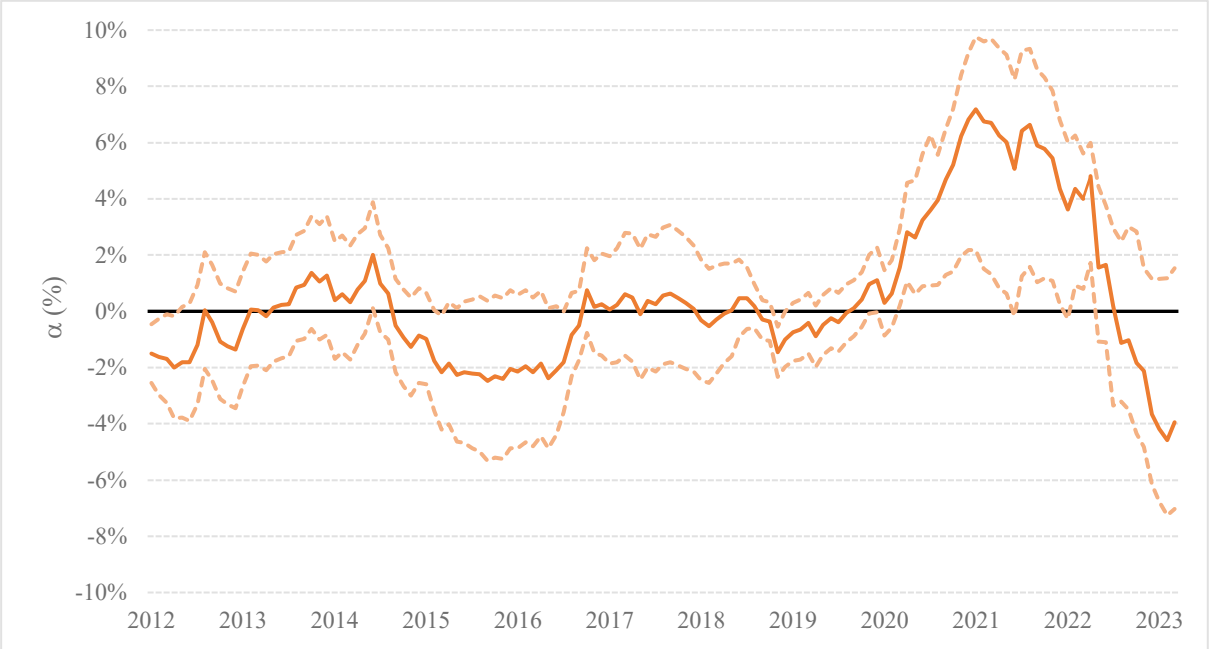


Figure 15

PE/VC IPOs Value Weighted Time-Varying Alpha Estimates

The figure displays the progression of alpha estimates for PE/VC IPOs over time, utilizing the expanded Fama and French model on returns from a value-weighted portfolio. We execute this estimation process employing a moving window analysis, incorporating 24 months' worth of observations at a time. The plotted 95% confidence bands, which signify two standard deviations, allow us to discern periods in the historical data when the risk-adjusted returns were statistically distinguishable from zero, based on a 5% level of significance.



Panel C: PE/VC-NS IPOs

When considering the entire data period, our estimated models reveal no significant variations in alphas. However, the market beta is statistically significant at 5% in the CAPM models. This outcome suggests that PE/VC-backed companies tend to outperform non-sponsored ones in a bear market according to the EW and VW portfolios.

For the Fama-French three-factors model the EW portfolio show negative and significant values for beta and SMB at 10% indicating an inverse relationship with the market and that the portfolio tends to perform better when large market cap stocks outperform small market cap stocks. The VW portfolio displays no significant values, but a negative alpha suggesting that PE/VC firms underperform NS firms.

In the extended Fama-French five-factor models which include additional liquidity and momentum factors, the coefficient for momentum (UMD) is negative and significant in both models at 10%. This observation suggests a reverse momentum effect for these IPOs, with

recent underperformers showing a propensity to outperform in the future, and vice versa. The EW portfolio also displays negative and significant values for beta and SMB like the $FF3_{EW}$.

Despite these observations, it's crucial to note that all models display an adjusted R^2 value below 0.15, which indicates a limited explanatory power of these models for the variance in the differential returns of PE/VC-backed and NS firms.

Ritter (1991) demonstrated that PE/VC-backed IPOs often display long-term underperformance compared to other firms. This may partially justify the observed negative and significant coefficients in the beta for $CAPM_{VW}$ and UMD for $FF5_{EW}$ and $FF5_{VW}$ models, however the alphas are mainly positive but not significant, this can be seen in the following figures where the PE/VC portfolio significantly (5%) underperform and outperform the NS portfolio for shorter time periods.

Figure 16

PE/VC-NS IPOs Equally Weighted Time-Varying Alpha Estimates

The figure displays the progression of alpha estimates for the excess return of PE/VC IPOs over time, utilizing the expanded Fama and French model on returns from a value-weighted portfolio. We execute this estimation process employing a moving window analysis, incorporating 24 months' worth of observations at a time. The plotted 95% confidence bands, which signify two standard deviations, allow us to discern periods in the historical data when the risk-adjusted returns were statistically distinguishable from zero, based on a 5% level of significance.

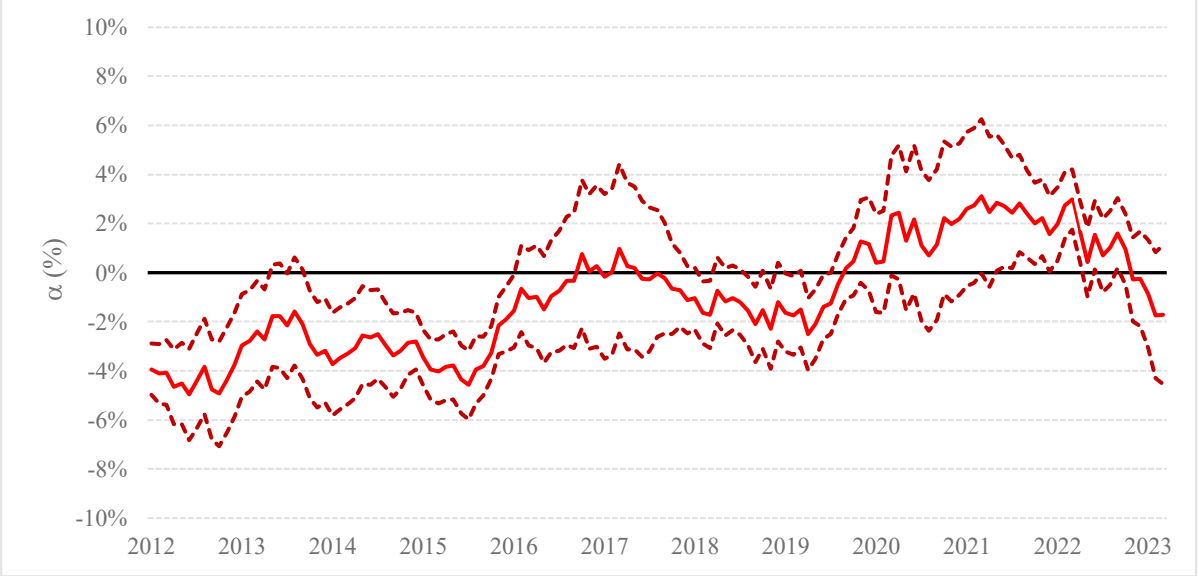
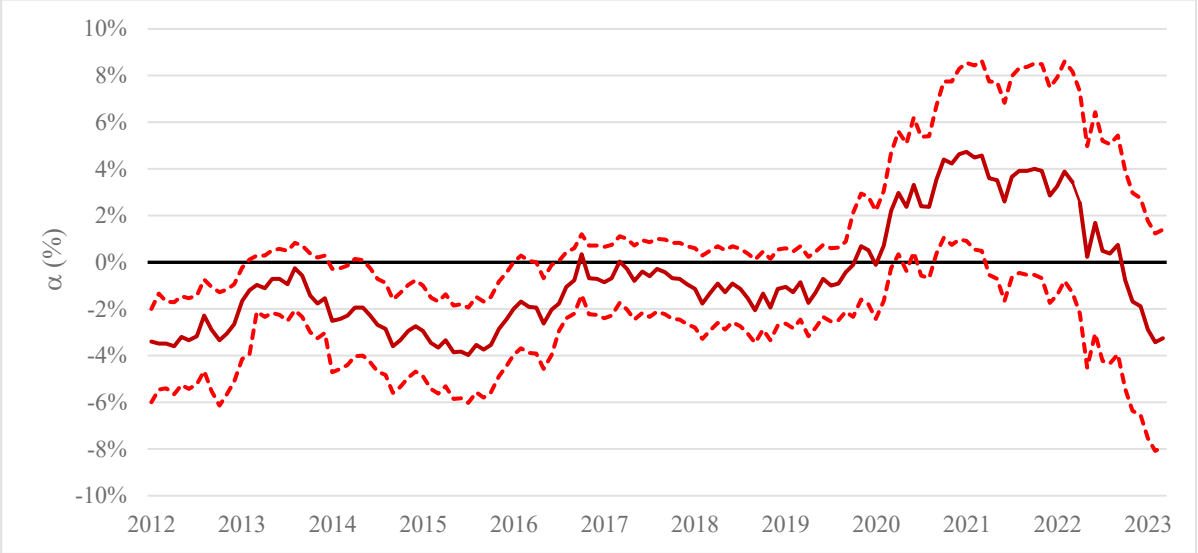


Figure 17

PE/VC-NS IPOs Value-Weighted Time-Varying Alpha Estimates

The figure displays the progression of alpha estimates for the excess return of PE/VC IPOs over time, utilizing the expanded Fama and French model on returns from a value-weighted portfolio. We execute this estimation process employing a moving window analysis, incorporating 24 months' worth of observations at a time. The plotted 95% confidence bands, which signify two standard deviations, allow us to discern periods in the historical data when the risk-adjusted returns were statistically distinguishable from zero, based on a 5% level of significance.



6.4 Results

In this section we will determine whether we keep or discard our six hypotheses, based on our analysis.

6.4.1 Underpricing

H_1: PE- and VC-sponsored firms display lower underpricing than non-sponsored firms

We reject H_1 for both equally and value-weighted samples, as our findings indicate that there is an equal average level of underpricing across all IPO groups. This conclusion stands valid at both the 5% and 10% significance levels.

H_2: Market capitalization affects underpricing

We reject H_2, meaning that market capitalization does not affect underpricing at a significant level, this conclusion stands valid at 5% significance.

H_3: The degree of underpricing is influenced by risk

We reject H_3 as we don't find significant results that the degree of underpricing is influenced by risk.

6.4.2 Long-Run Performance

H_4: PE- and VC-sponsored firms display better long-run performance than non-sponsored firms

We reject H_4 as there is no definitive evidence to suggest that PE/VC-backed firms consistently show superior long-run performance as compared to their NS counterparts. Whether we look at the CARs or the BHRs, or even the WRs over the years, none of these metrics conclusively indicate a steady outperformance by the PE/VC-backed firms. Although we have not conducted t-tests to compare the differences in CARs due to significant variations in sample sizes, it is noteworthy to observe that VW portfolio of PE/VC-backed IPOs display considerably negative performance compared to the index and other firms. However, NS VW portfolio performs slightly better than the PE/VC VW portfolio.

H_5: Market capitalization affect long-run performance

We keep H_5, as we find that market capitalization does affect long-run performance. Both the PE/VC and NS VW portfolios registered positive returns and outperformed the index between the 9th and 18th months post-IPO, suggesting that the size of a firm does have a bearing on its performance, at least in the short term. NS firms, with their substantial market capitalization, consistently outperformed other portfolios, further demonstrating the significance of market size on post-IPO performance. Our data suggest that market capitalization does influence the long-run performance of firms post-IPO. Large firms such as Kahoot and Nykode Therapeutics for the PE/VC portfolio, and Adevinta and Gjensidige Forsikring for the NS portfolio, carry substantial market capitalization weight, thereby exerting a significant influence on portfolio returns.

H_6: PE- and VC-sponsored firms display different risk-adjusted returns than non-sponsored firms

Our analysis shows that PE/VC-sponsored IPOs display significant time variation in their performance compared to NS IPOs. While overall alphas do not differ significantly, the aftermath of the COVID-19 pandemic reveals a period where PE/VC outperforms NS IPOs, particularly among larger issues. However, leading up to the pandemic PE/VC underperform relative to NS firms. For shorter periods between 2012 and 2016 the PE/VC firms significantly underperforms compared to NS. From the start of the test period till the start of 2013 the PE/VC significantly underperforms relatively to the NS portfolio and from a period from mid 2014 to the end of 2015. We add that there is considerable time-variation in both risk exposures and performance differences at the 5% level of significance, and we keep H_6 as a result.

7. Conclusion

7.1 Underpricing

According to the initial sample, larger PE/VC IPOs are underpriced more frequently than NS IPOs in specific circumstances. However, adjusting for outliers reveals a larger decrease in underpricing for PE/VC-backed IPOs compared to NS IPOs, supporting that smaller PE- and VC-sponsored firms exhibit less underpricing, although the differences aren't statistically significant. Before and after trimming the PE/VC firms display a larger underpricing than NS, but not significantly. On the issue of size, market capitalization doesn't appear to significantly influence underpricing. Furthermore, we find that risk doesn't substantially impact underpricing, even after adjusting for outliers. Lastly, when evaluating portfolios year by year, underpricing levels don't show major disparities over time (apart from 2010), suggesting that the relative sample sizes of yearly IPO cohorts don't significantly influence underpricing.

7.2 Long-run performance

To assess and analyze the long-term performance of various IPO groupings, we employ a selection of approaches. CAR demonstrates an underperformance of PE/VC-backed IPOs, compared to the index but also for larger firms compared to NS firms. Smaller PE/VC-backed IPOs perform worse than NS IPOs, and both underperform in comparison to the OSEBX. Larger NS IPOs, on the other hand, perform better than other IPOs, with results generally robust to outliers. But after outliers are considered, we observe that the larger PE/VC IPO portfolio's abnormal short-term performance rises.

In initial observations, BHR calculations reveal significant differences in WR over time between IPO groups. But these differences tend to be more influenced by market dynamics than by active ownership, and periods of pronounced differences often correspond to small sample sizes. PE/VC and NS IPOs show similar values both in the short and long run.

Risk-adjusted return calculations display annualized alphas for PE/VC IPOs ranging from -4.9% to 16.8%, across all models and both PE/VC portfolios. None of the models yield significant alphas. The range for NS IPOs' annualized alphas is from -10.8 % to 8.7%, with similar findings concerning the significance of the alphas.

A regression on the excess return of PE/VC IPOs across the full 159-month sample period shows no significant differences in returns, but the value-weighted portfolios indicate some underperformance of PE/VC IPOs over the full period.

The relative long-run performance and risk exposures are further clarified by our monthly time-varying estimates using rolling regressions. Both equally and value-weighted PE/VC IPOs beat NS IPOs for a brief period during the Covid-19 epidemic. Additionally, between 2012 and 2016, the PE/VC underperformed in comparison to NS for various periods.

Market exposure for value-weighted PE/VC IPOs was minimal leading up to the Covid-19 pandemic, before falling drastically and then stabilizing again (Appendix 9.6). The equally-weighted PE/VC IPO portfolio exhibited a growth tilt before Covid-19 and showed notable market and value exposure leading up to the pandemic, where it shortly after drastically fall.

7.3 Limitations and future research

This study may have several limitations, particularly in relation to our dataset. While the original sample consists of 130 firms, it could benefit from being larger. This limitation is a result of our selected analysis period, as well as the period that is covered by the data provided to us from Argentum. A way of mitigating this limitation could be by including the other Nordic countries. It is also worth mentioning that the methodology we have employed in this thesis was originally used on firms that went public in the U.S., which could have different characteristics than firms in the Norwegian IPO market. Lastly, the possibility of omitted variable bias is present, which can bias our estimation.

Concerning future research, it could be interesting to analyze a sample that covers a longer period than our analysis. As our data begins shortly after the finical crisis of 2008, the IPO activity is low compared to the years before the crash.

8. References

Ahmad-Zaluki, N. A., Campell, K., & Goodacre, A. (2007). The Long Run Share Price Performance of Malaysian Initial Public Offerings (IPOs). *Journal of Business Finance and Accounting 34 (1) & (2)*, pp. 78-110.

(GPFG), G. P. (2021). *About the fund*. Retrieved from https://www.nbim.no/en/the-fund/about-the-fund/

Bain & Company. (2014). *Bain & Company's Global Private Equity Report 2014.* Retrieved from https://www.bain.com/insights/global-private-equity-report-2014/

Bergström, C., Nilsson, D., & Wahlberg, M. (2006). Underpricing and Long-Run Performance Patterns of European Private-Equity-Backed and Non-Private-Equity-Backed IPOs. *The Journal of Private Equity, 9(4)*, pp. 16-47.

Berk, J., & DeMarzo, P. (2020). *Corporate Finance.* Global Edition: Pearson.

Bessembinder, H., & Zhang, F. (2013). Firm characteristics and long-run stock returns after corporate events. *Journal of Financial Economics*, pp. 83-102.

Brav, A., & Gompers, P. A. (1997). Myth or Reality? The Long-Run Underperformance of Initial Public Offerings: Evidence from Venture and Nonventure Capital-Backed Companies. *The Journal of Finance, 52*, pp. 1791-1821.

Brennan, M., & Franks, J. (1997). Underpricing, Ownership and Control in Initial Public Offerings of Equity Securities in the U.K. *Journal of Financial Economics 45*, pp. 391-413.

Brooks, C. (2008). *Introductory Econometrics for Finance: Second Edition.* Cambridge University Press.

Buchner, A., Mohamed, A., & Niklas Wagner. (2019). Are venture capital and buyout backed IPOs any different? *Journal of International Financial Markets, Institutions and Money, Volume 60*, pp. 39-49.

Busenitz, W. D., Matsuik, S., Townsend, D., Anglin, A., & Dushnitsky, G. (2017). A Review and Road Map of Entrepreneurial Equity Financing Research: Venture Capital, Corporate Venture Capital, Angel Investment, Crowdfunding, and Accelerators. *Journal of Management Vol. 43 No. 6*, pp. 1820-1853.

Cao, J., & Lerner, J. (2009). The Performance of Reverse Leveraged Buyouts. *Journal of Finacial Economics*, pp. 139-157.

Cao, J., Jiang, F., & Ritter, J. R. (2005). Patents, Innovation, and Performance of Venture Capital-backed IPOs.

Carhart, M. M. (1997). On Persistence in Mutual Fund Performance. *The Journal of Finance, 52(1)*, pp. 57-82.

Cendrowski, H., Petro, L. W., Martin, J. P., & Wadecki, A. A. (2012). *Private Equity: History, Governance and Operations, Second Edition.* John Wiley & Sons, Inc.

Da Silva Rosa, R., Velayuthen, G., & Walter, T. (2003). The sharemarket performance of Australian venture capital-backed and non-venture capital-backed IPOs. *Pacific-Basin Finance Journal Vol. 11, Issue 2*, pp. 197-218.

Das, Sanjiv, Jagannathan, M., & Sarin, A. (2003). Private equity returns: an empirical examination of the exit of venture-backed companies. *Journal of Investment Management, 1(1)*, pp. 152-177.

Demaria, C. (2013). *Introduction to Private Equity, Second Editon.* John Wiley & Sons, Ltd. .

EuroNext. (2022). *IPO Guide.* Retrieved from https://info.euronext.com/ipoguide/

EuroNext. (2023a). *Index Rule Book.* Retrieved from EuroNext Live Markets: https://live.euronext.com/sites/default/files/documentation/index-rules2/OBX_Index_Family_Rulebook.pdf

EuroNext. (2023b). *Oslo Børs*. Retrieved from https://www.euronext.com/en/markets/oslo

EuroNext. (2023c). *Stocks Oslo*. Retrieved from https://live.euronext.com/en/markets/oslo/equities/list

EuroNext. (2023d). *The IPO Journey*. Retrieved from https://www.euronext.com/en/raise-capital/how-go-public/ipo-journey

Fama, E. F., & French, K. R. (1992). The Cross-Section of Expected Stock Returns. *The Journal of Finance, 47(2)*, pp. 427-465.

Fama, E. F., & French, K. R. (1998). Value versus Growth: The International Evidence. *The Journal of Finance, vol. 53, no. 6*, pp. 1975-1999.

Fama, E. F., & French, K. R. (2004). The Capital Asset Pricing Model: Theory and Evidence. *Journal of Economic Perspectives, American Economic Association, vol. 18(3)*, pp. 25-46.

Fama, E., & French, K. R. (2023). *Detail for Monthly Momentum Factor (Mom)*. Retrieved from Current Research Returns: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_mom_factor.html

Føllesdal, S., & Hagen, E. N. (2013). *Private Equity-Backed Firms' Performance Post IPO.* Retrieved from [Master's thesis]: https://openaccess.nhh.no/nhh-xmlui/bitstream/handle/11250/191728/Hagen_Follesdal_2013.pdf?sequence=1&isAllowed=y

Fenn, G. W., Liang, N., & Prowse, S. (1996). The Economics of the Private Equity Market. *Federal Reserve Bulletin*.

Fleming, M. J. (2000). *The Benchmark U.S. Treasury Market: Recent Performance and Possible Alternatives.* Retrieved from https://www.newyorkfed.org/medialibrary/media/research/epr/00v06n1/0004flem.pdf

Folus, D., & Boutron, E. (2015). Exit Strategies in Private Equity. In H. K. Baker, G. Filbeck, & H. Kiymaz, *Private Equity: Opportunities and Risks.* Oxford University Press.

Gilligan, J., & Wright, M. (2014). *Private equity demystified: An explanatory guide.* ICAEW.

Gompers, P. A., & Lerner, J. (2003). The Really Long-Run Performance of Initial Public Offerings: The Pre-Nasdaq Evidence. *The Journal of Finance, Vol. 58, Issue 4*, pp. 1335-1747.

Griffin, J. M. (2002). Are the Fama and French Factors Global or Country Specific? *The Review of Financial Studies, vol. 15, no. 3*, pp. 783-803.

Grossman, J. S., & Hart, O. D. (1980). Takeover Bids, The Free-Rider Problem, and the Theory of the Corporation. *The Bell Journal of Economics, Vol. 11, No. 1*, pp. 42-64.

Gundersen, G. (2022). *Returns and Log Returns*. Retrieved from https://gregorygundersen.com/blog/2022/02/06/log-returns/

Ibbotson, R. G., & Jaffe, J. F. (1975). 'Hot Issue' Markets. *The Journal of Finance, 30(4)*, pp. 1027–1042.

Ivashina, V., & Kovna, A. (2011). The Private Equity Advantage: Leveraged Buyout Firms and Relationship Banking. *The Review of Financial Studies, 24(7)*, pp. 2462-2498.

Jenkinson, T., & Ljungqvist, A. (2001). *Going Public: The Theory and Evidence on how Companies Raise Equity Finance.* Oxford University Press.

Jensen, M. C. (1986). Agency Costs of Free Cash Flow. *American Economic Review, 76(2)*, pp. 323-329.

Jensen, M. C. (1989). Eclipse of the Public Corporation. *Harvard Buisness Review, 67(5)*, pp. 61-74.

Kaplan, N. S., & Strömberg, P. (2009). Leveraged Buyoys and Private Equity. *The Journal of Economic Perspectives , Winter, 2009, Vol. 23, No. 1*, pp. 121-146.

Katti, S., & Phani, B. V. (2016). Underpricing of Initial Public Offerings: A Literature Review. *Universal Journal of Accounting and Finance 4*, pp. 35-52.

Kooli, M., & Suret, J.-M. (2004). The aftermarket performance of initial public offerings in Canada. *Journal of Multinational Financial Management, Volume 4, Issue 1*, pp. 47-66.

Levis, M. (2011). The Performance of Private Equity-Backed IPOs. *Financial Management, 40(1)*, pp. 253-277.

Ljungqvist, A. (2004). Chapter III.4: IPO Underpricing. In B. E. Eckbo, *Handbook in Corporate Finance: Empirical Corporate Finance.*

Loughran, T. (1993). NYSE vs NASDAQ returns: Market microstructure or the poor performance of initial public offerings? *Journals of Financial Economics, Volume 33, Issue 2*, pp. 241-266.

Loughran, T., & Ritter, J. R. (1995). The New Issues Puzzle. *The Journal of Finance, Volume 50, Issue 1*, pp. 23-51.

Loughran, T., & Ritter, J. R. (2002). Why Don't Issuers Get Upset about Leaving Money on the Table in IPOs? *The Review of Financial Studies*, pp. 413-443.

Loughran, T., Ritter, J. R., & Rydqvist, K. (1994). Initial public offerings: International insights. *Pacific-Basin Finance Journal 2(2-3)*, pp. 165-199.

Ma, J., Pagán, J. A., & Chuc, Y. (2009). Abnormal Returns to Mergers and Acquisitions in Ten Asian Stock Markets. *International Journal of Business, 14(3)*, pp. 235-250.

Ma, T., & Shen, Y. (2003). Prospect Theory and the Long-Run Performance of IPO Stocks. *4th Annual Conference on Financial Economics and Accounting (FEA)*, pp. 1-26.

Müller, H. M., & Panunzi, F. (2004). Tender offers and leverage. *The Quarterly Journal of Economics, Vol. 119, No. 4*, pp. 1217-1248.

Megginson, W., & Weiss, A. (1991). Venture Capitalist Certification in Initial Public Offerings . *Journal of Finance, vol. 46, issue 3*, pp. 879-903.

Mehrothra, V., Schaede, U., & Tørresen, S. (2011). From Government to Governance: A Study of the Norwegian State as an Active Owner. *Journal of Applied Corporate Finance, 23(4)*, pp. 71-80.

Metrick, A., & Yasuda, A. (2011). *Venture Capital & The Financa of Innovation, Second Edition.* John Wiley & Sons.

Miller, E. M. (1977). Risk, Uncertainty, and Divergence of Opinion. *The Journal of Finance, Volume 32, No. 4*, pp. 1151-1168.

Morningstar. (2023). *OSE Oslo Børs Benchmark TR NOK*. Retrieved from https://www.morningstar.com/indexes/xosl/osebx/quote

MSCI. (n.d). *Focus: Momentum.* Retrieved from Factor Investing: https://www.msci.com/documents/1296102/1339060/Factor+Factsheets+Momentum.pdf/a766ef6b-cd24-4460-8163-900323fc2957

Newey, W. K., & West, K. D. (1987). A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica, 55(3)*, pp. 703–708.

Norwegian Venture Capital Assosiation. (2022). *Private Equity Fonds in Norway - Activity Rapport 2021.* Menon Economics.

Pastor, L., & Stambaugh, R. F. (2019). Liquidity Risk After 20 Years. *Chicago Booth Research Paper No. 19-13, Fama-Miller Working Paper*.

Pástor, Ľ., & Stambaugh, R. F. (2003). Liquidity Risk and Expected Stock Returns. *Journal of Political Economy, 111(3)*, pp. 642–685.

Preqin. (2016). *2016 Preqin Global Private Equity & Venture Capital Report.* Retrieved from Sample Pages: https://docs.preqin.com/samples/2016-Preqin-Global-Private-Equity-and-Venture-Capital-Report-Sample_Pages.pdf

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

Rock, K. (1986). Why New Issues Are Underpriced. *Journal of Financial Economics 15*, pp. 187-212.

Sapienza, H. J. (1992). When do venture capitalists add value? *Journal of Business Venturing, 7(1)*, pp. 9-27.

Schuster, J. A. (2003). IPOs: insights from seven European countries. *Financial Markets Group, London School of Economics and Political Science: Discussion paper*, pp. 1-39.

Shiller, R. J. (1988). Initial Public Offerings: Investor Behavior and Underpricing. *National Bureau of Economic Research Working Paper Series*.

Shleifer, A., & Summers, L. H. (1988). Breach of Trust in Hostile Takeovers. *University of Chigago Press*, pp. 33-56.

Snow, D. (n.d.). *Private equity: A Brief Overview.* PEI MEDIA.

Stock, J. H., & Watson, M. W. (2020). *Introduction to Econometrics (4th edition).* Global Edition: Pearson Education.

Stoughton, N. M., & Zechner, J. (n.d.). IPO Mechanisms, Monitoring and Ownership Structure. *Journal of Financial Economics 49*, pp. 45-78.

Teoh, S. H., Welch, I., & Wong, T. (1998). Earnings Management and the Long-Run Market Performance of Initial Public Offerings. *The Journal of Finance, Volume 53, Issue 6*, pp. 1935-1974.

Womack, K., & Zhang, Y. (2003). *Understanding Risk and Return, the CAPM, and the Fama-French Three-Factor Model.* Retrieved from https://www.researchgate.net/publication/228169038_Understanding_Risk_and_Return_the_CAPM_and_the_Fama-French_Three-Factor_Model/

Wooldridge, J. M. (2018). *Introductory Econometrics - A modern Approach, 7e.* Boston: Cengage Learning.

Ødegaard, B. A. (2017). *Bond Liquidity at the Oslo Stock Exchange.* Retrieved from https://ba-odegaard.no/publications/2017_bond_liquidity_OSE/staff_memo_5_2017_eng.pdf

Ødegaard, B. A. (2023). *Asset pricing data at OSE*. Retrieved from https://ba-odegaard.no/financial_data/ose_asset_pricing_data/index.html

9. Appendix

9.1 Gauss-Markov assumptions for cross-sectional regressions

(Wooldridge, 2018, pp. 103-104)

1. **Linear in Parameters**

   The model in the population can be written as:

   $$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + u$$

   Where $\beta_0, \beta_1, \dots, \beta_k$ are the unknown parameters (constants) of interest and u is an unobserved random error or disturbance term.

2. **Random Sampling**

   We have a random sample of n observations, $\{(x_{i1}, x_{i2}, \dots, x_{ik}, y_i): i = 1,2, \dots, n\}$ following the population model in Assumption 1.

3. **No Perfect Collinearity**

   In the sample (and therefore the population), none of the independent variables is constant, and there are no *exact linear* relationships among the independent variables.

4. **Zero Conditional Mean**

   The error u has an expected value of zero given any values of the independent variables. In other words,

   $$E(u|x_1, x_2, \dots, x_k) = 0.$$

5. **Homoskedasticity**

   The error u has the same variance given any value of the explanatory variables. In other words,

   $$Var(u|x_1, \dots, x_k) = \sigma^2.$$

6. **Normality**

   The error u is independent of $\boldsymbol{X}$ and is independently and identically distributed as $Normal(0, \sigma^2)$

9.2 Classic linear model assumptions for time series regressions

(Wooldridge, 2018, pp. 360-361)

1. **Linear in Parameters**

   The stochastic process $\{(x_{t1}, x_{t2}, \dots, x_{tk}, y_t): t = 1,2, \dots, n\}$ follow the linear model:

   $$y_t = \beta_0 + \beta_1 x_{t1} + \beta_2 x_{t2} + \cdots + \beta_k x_{tk} + u_t$$

   Where $\{u_t: t = 1,2, \dots, n\}$ is the sequence of errors or disturbances. Here, n is the number of observations (time periods).

2. **No Perfect Collinearity**

   In the sample (and therefore in the underlying time series process), no independent variable is constant nor a perfect linear combination of the others.

3. **Zero Conditional Mean**

   For each t, the expected value of the error u_t, given the explanatory variables for *all* time periods, is zero. Mathematically,

   $$(u_t|\boldsymbol{X}) = 0, t = 1,2, \dots, n.$$

4. **Homoskedasticity**

   Conditional on $\boldsymbol{X}$, the variance of u_t is the same for all t:

   $$Var(u_t|\boldsymbol{X}) = Var(u_t) = \sigma^2, t = 1,2, \dots, n.$$

5. **No Serial Correlation**

   Conditional on $\boldsymbol{X}$, the errors in two different time periods are uncorrelated:

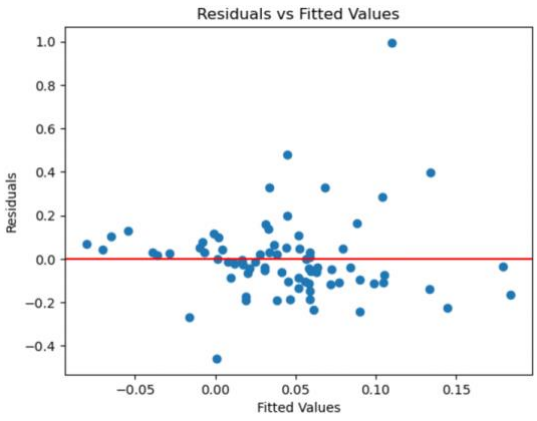
   $$Corr(u_t, u_s|\boldsymbol{X}) = 0, \text{ for all } t \neq s.$$

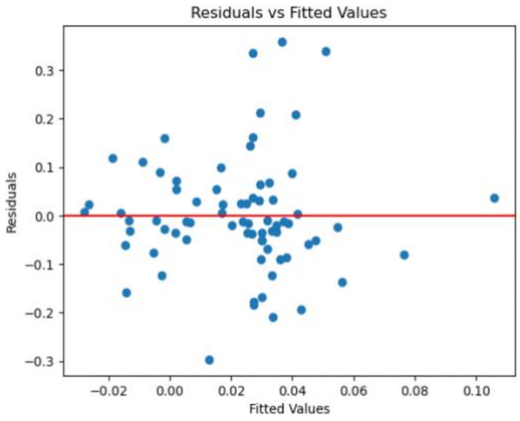
6. **Normality**

   The errors u_t are independent of $\boldsymbol{X}$ and are independently and identically distributed as $Normal(0, \sigma^2)$

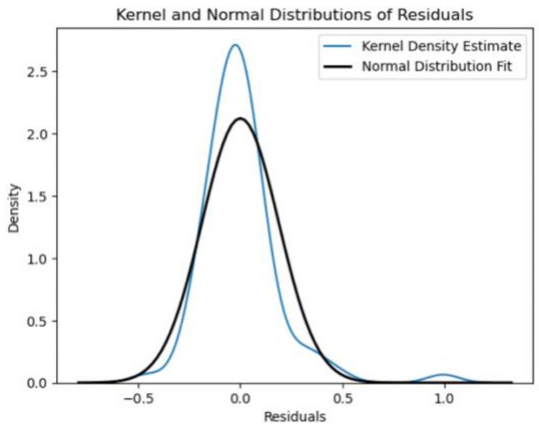
9.3 Diagnostic plots: residuals - underpricing

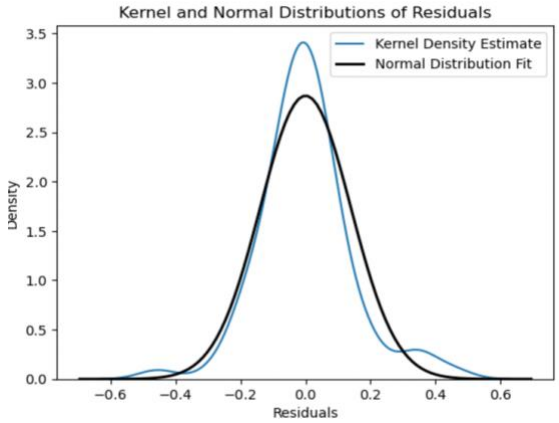
The residuals of the initial underpricing sample are shown in the graph on the left. The residuals of the underpricing sample are shown in the graph on the right after we excluded the initial returns of IDEX ASA.





The graph on the left shows the normal density distribution given the sample's mean and variance together with the residual density distribution from the original underpricing sample. After removing the original returns of IDEX ASA, the graph on the right shows the residual density distribution of the underpricing sample along with the resulting normal density distribution.





9.4 Dickey-Fuller tests

Data	Test Statistic	1% critical value	5% critical value	10% critical value
NS_EW	-10,704	-3,482	-2,884	-2,579
NS_VW	-11,954	-3,482	-2,884	-2,579
PE/VC_EW	-11,027	-3,482	-2,884	-2,579
PE/VC_VW	-5,803	-3,482	-2,884	-2,579
RM	-11,489	-3,482	-2,884	-2,579
OSESX-OBX	-10,606	-3,482	-2,884	-2,579
HML	-8,967	-3,483	-2,885	-2,579
UMD	-7,164	-3,483	-2,884	-2,579
LIQ	-8,898	-3,484	-2,885	-2,579
PE/VC-NS_EW	-11,437	-3,484	-2,885	-2,579
PE/VC-NS_VW	-4,736	-3,484	-2,885	-2,579

9.5 Auto-Correlation tests

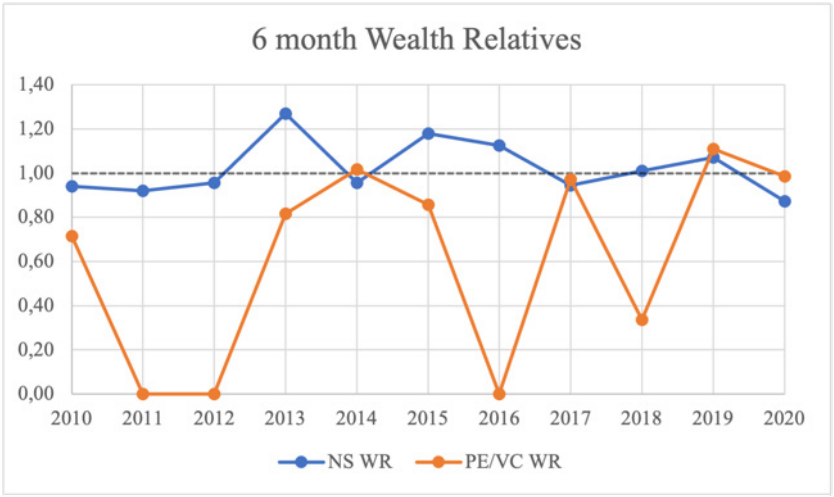
Breusch Godfrey test for autocorrelation

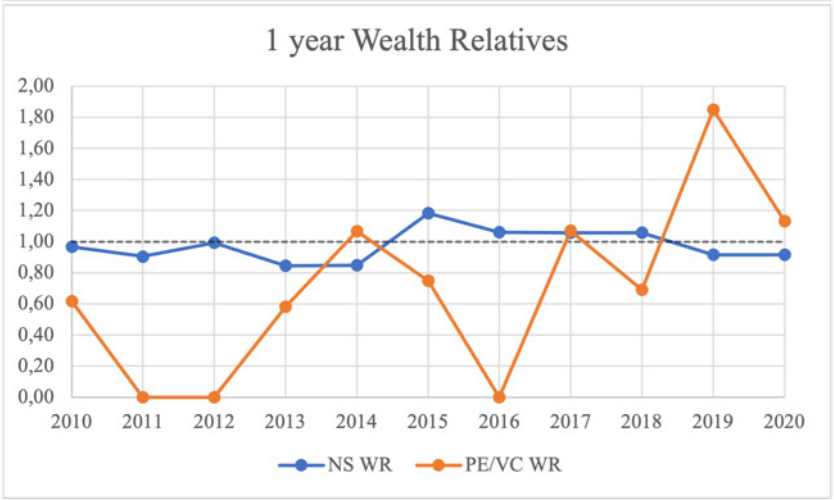
	CAPM		FF3		FF5	
	F-Value	**Prob > F**	**F-Value**	**Prob > F**	**F-Value**	**Prob > F**
NS_EW	0,157	0,689	0,247	0,619	0,091	0,754
NS_VW	1,937	0,163	0,231	0,631	0,210	0,647
PE/VC_EW	0,068	0,794	0,321	0,571	0,132	0,716
PE/VC_VW	0,840	0,359	0,341	0,559	2,407	0,121
PE-NS_EW	0,054	0,816	0,131	0,717	0,002	0,969
PE-NS_VW	0,002	0,961	0,095	0,758	0,010	0,752

9.6 Additional figures

Figure 18
Wealth Relatives from 2010 to 2020

The three graphs visualize how the Wealth Relatives vary over time in 6-month, 1-year, and 3-year Buy-and-Hold Return periods for both non-sponsored (NS) and PE/VC-sponsored firms. The dotted line indicates a Wealth Relative equal to 1, all values over the line indicates that the IPOs outperformed the OSEBX and vice versa. All values at 0 are due to unavailable data, such as no PE/VC IPOs in certain years.





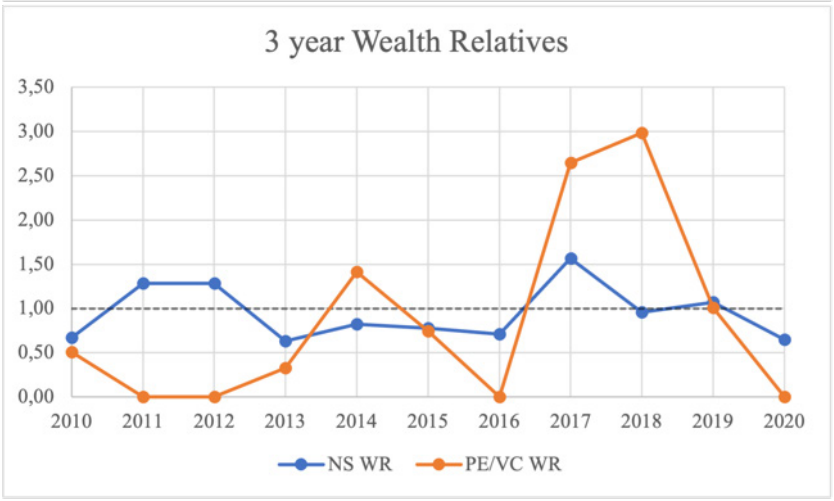


Figure 19

Time-Varying Factor Exposures to the Market Returns

The figure illustrates the time-varying exposures for all portfolios in relation to the to the market return of OSEBX, as analyzed through the augmented Fama and French model. This model is evaluated employing a rolling window methodology, consisting of 24-month intervals. The depicted market risk premium exposure (β), exceeding one, represents the threshold for full market exposure.

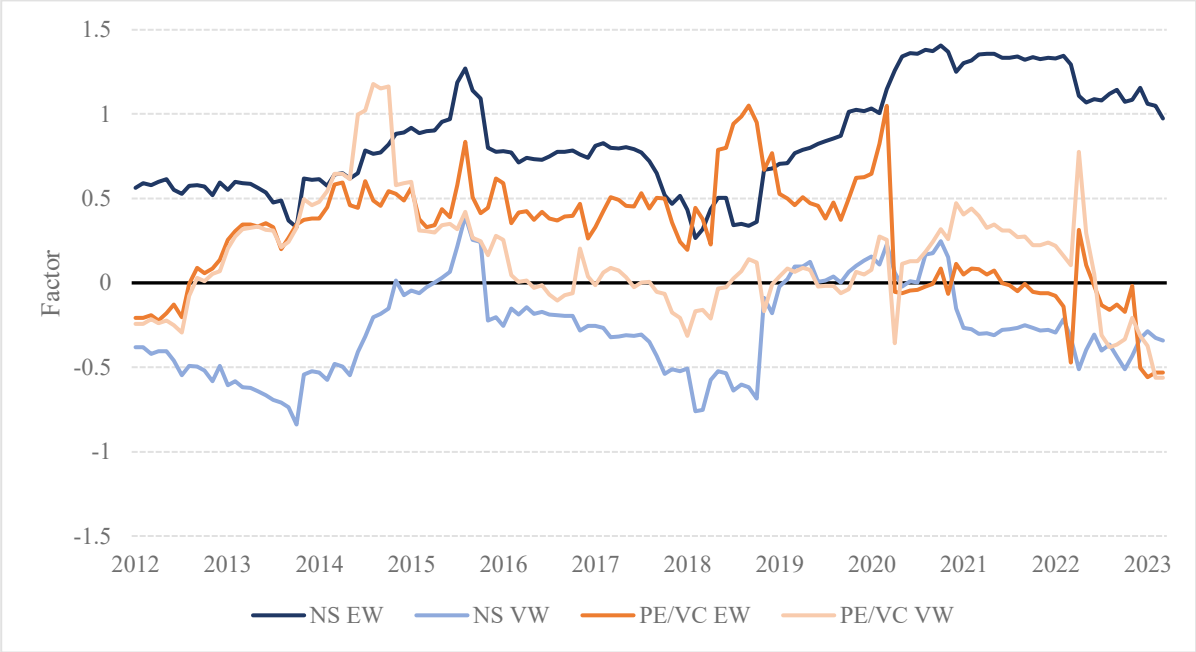


Figure 20

Time-Varying Factor Exposures to the SMB Portfolio

The figure illustrates the time-varying exposures for all portfolios in relation to the SMB portfolio, using the augmented Fama and French model. We create the SMB portfolio by establishing a long position in the OSESX index and concurrently holding a short position in the OBX index. We estimate this model using a rolling methodology that encompasses 24 monthly observations.

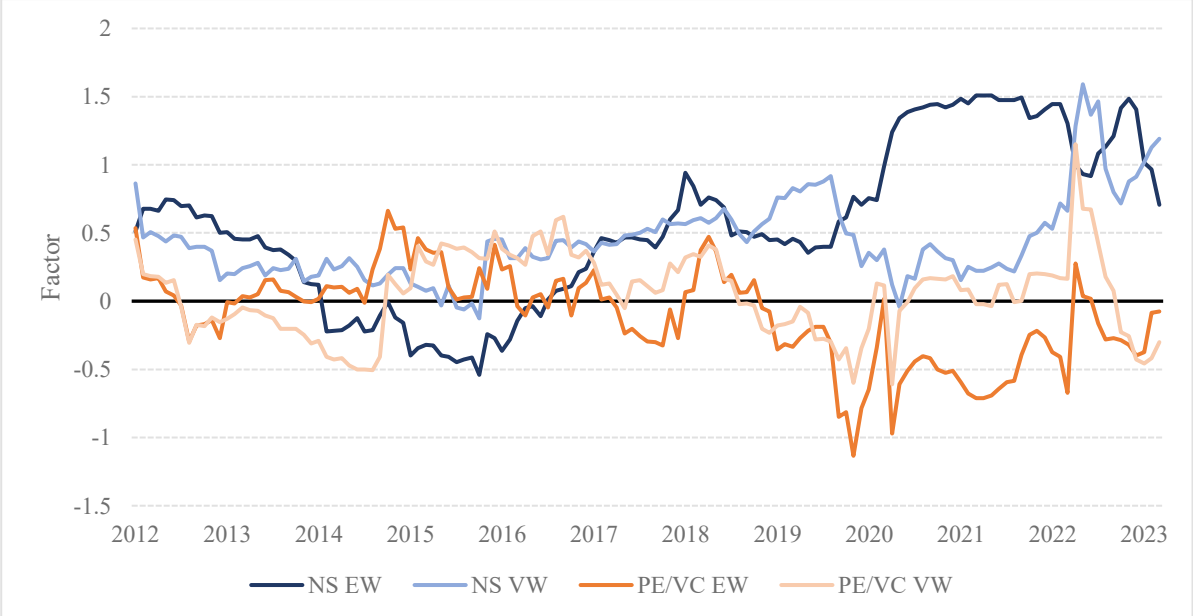


Figure 21

Time-Varying Factor Exposures to the HML Portfolio

The figure illustrates the time-varying exposures for all portfolios in relation to the HML portfolio, using the augmented Fama and French model. We retrieve the HML portfolio from Ødegaards' website and estimate this model using a rolling methodology that encompasses 24 monthly observations.

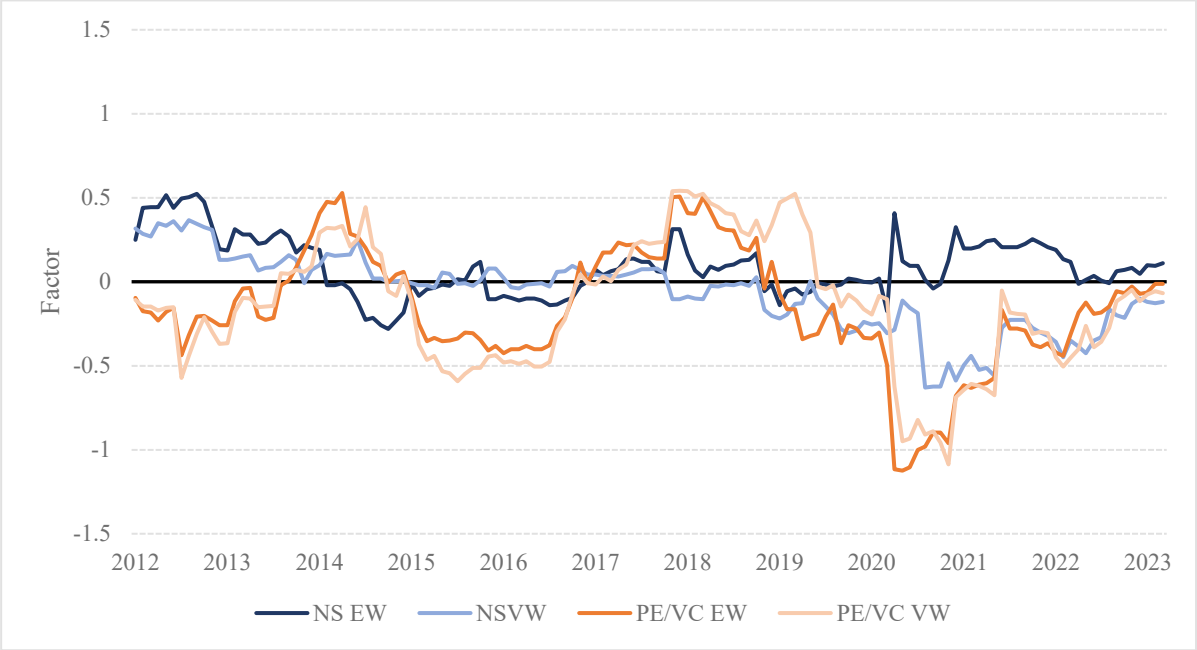


Figure 22

Time-Varying Factor Exposures to the UMD Portfolio

The figure illustrates the time-varying exposures for all portfolios in relation to the UMD portfolio, using the augmented Fama and French model. We retrieve the UMD portfolio from Ødegaards' website and estimate this model using a rolling methodology that encompasses 24 monthly observations

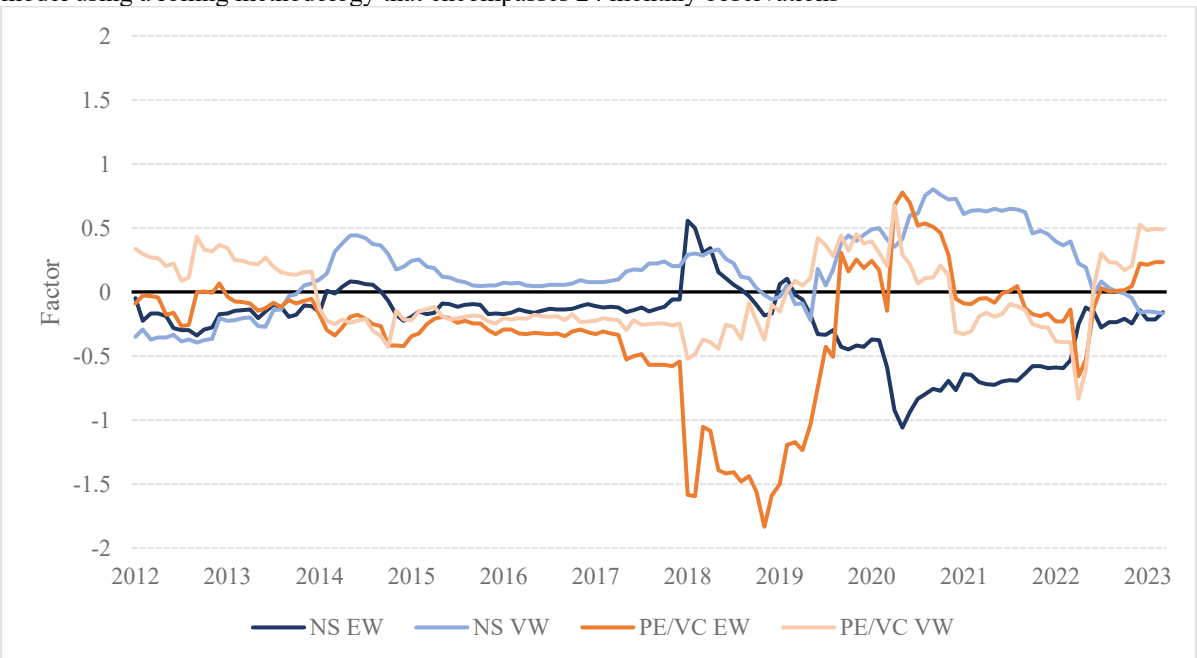
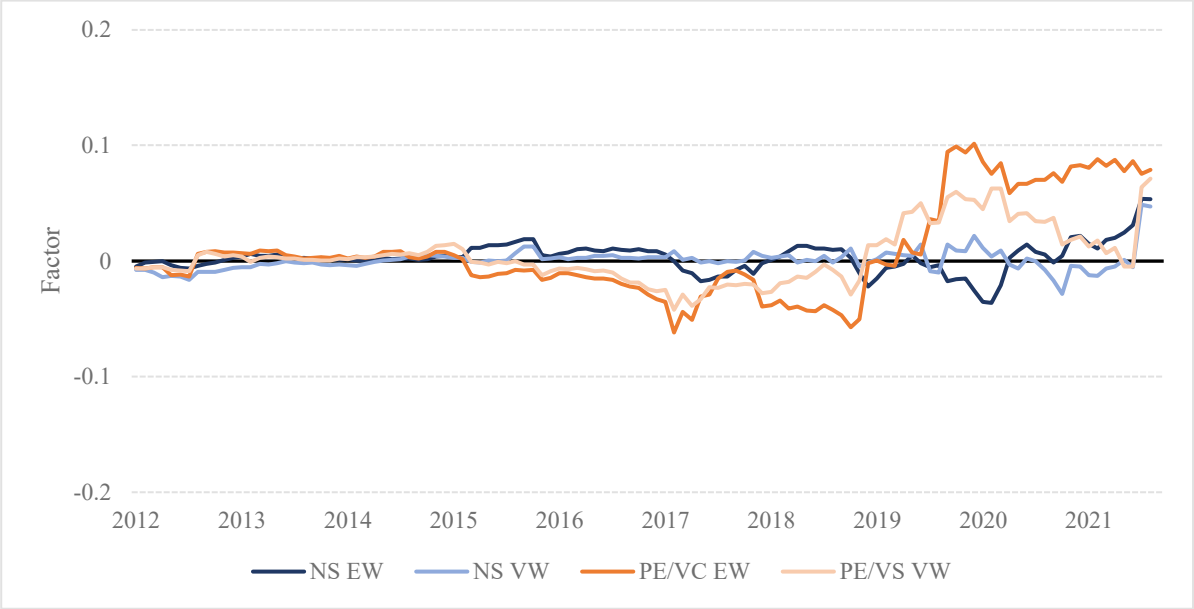


Figure 23

Time-Varying Factor Exposures to the LIQ Portfolio

The figure illustrates the time-varying exposures for all portfolios in relation to the LIQ portfolio, using the augmented Fama and French model. We retrieve the LIQ portfolio from Ødegaards' website and estimate this model using a rolling methodology that encompasses 24 monthly observations



9.7 Additional tables

Table 15
Overview of Private Equity Companies in Norway
(Norwegian Venture Capital Assosiation, 2022)

Venture	Buyout	Family Offices
Alliance Venture	Adelis Equity	Aars
Analysys Mason Ventures	Altor	Ferd Capital
Hadean Ventures	Axcel	
Investinor	EV Private Equity	
Idekapital	Equip Capital	
Northzone	EQT	
Nysnø Klimainvesteringer	FSN Capital	
Proventure	HitecVision	
Sarsia Seed	Longship	
Skagerak Capital	Nordic Capital	
SNÖ	Norvestor	
Viking Venture	Reiten & Co	
	Summa Equity	
	Triton	
	Verdane Capital	
	Waterland	

Table 16
Equally weighted average initial returns for 55 countries
(Loughran, Ritter & Rydqvist (1994, updated 2023)

Country	Source	Sample Size	Time Period	Avg. Initial Return
Argentina	Eijgenhuijsen & van der Valk; Dealogic	30	1991-2018	5.7%
Australia	Lee, Taylor & Walter; Woo; Pham; Dealogic	2,377	1976-2021	20.5%
Austria	Aussenegg; Dealogic	106	1971-2018	6.2%
Belgium	Rogiers, Manigart & Ooghe; Manigart DuMortier; Dealogic	154	1984-2017	11.0%
Brazil	Aggarwal, Leal & Hernandez; Saito; Ushisima; Dealogic	310	1979-2019	29.6%
Bulgaria	Nikolov	9	2004-2007	36.5%
Canada	Jog & Riding; Jog & Srivastava; Kryzanowski, Lazrak & Rakita; Dealogic	811	1971-2021	6.8%
Chile	Aggarwal, Leal & Hernandez; Celis & Maturana; Dealogic	88	1982-2019	6.8%
China	Chen, Choi, & Jiang; Jia, Xie, Zhang, & Ritter; Qian; Jin; Dealogic; Jia	4,983	1990-2022	162.2%
Cyprus	Gounopoulos, Nounis, and Stylianides; Chandriotis	73	1997-2012	20.3%
Denmark	Jakobsen & Sorensen; Dealogic	190	1984-2021	7.6%
Egypt	Omran; Hearn	74	1990-2017	9.4%
Finland	Keloharju; Dealogic	244	1971-2021	14.5%
France	Husson & Jacquillat; Leleux & Muzyka; Paliard & Belletante; Derrien & Womack; Chahine; Ritter; Vismara; Dealogic	904	1983-2021	9.4%
Germany	Ljungqvist; Rocholl;Vismara; Dealogic	840	1978-2020	21.8%
Greece	Nounis, Kazantzis & Thomas; Thomadakis, Gounopoulos & Nounis	373	1976-2013	50.8%
Hong Kong	McGuinness; Zhao & Wu; Ljungqvist & Yu; Fung, Gul, and Radhakrishnan; Dealogic	2,301	1980-2021	40.5%
India	Marisetty and Subrahmanyam; Dealogic Seth using Chittorgarh.com	3,202	1990-2020	84.0%
Indonesia	Suherman; Dealogic	697	1990-2020	56.0%
Iran	Bagherzadeh	279	1991-2004	22.4%
Ireland	Dealogic	38	1991-2013	21.6%
Israel	Kandel, Sarig & Wohl; Amihud & Hauser; Ritter	348	1990-2006	13.8%
Italy	Arosio, Giudici & Paleari; Cassia, Paleari & Redondi; Vismara; Dealogic	413	1985-2018	13.1%
Japan	Fukuda; Dawson & Hiraki; Hebner & Hiraki; Pettway & Kaneko; Hamao, Packer, & Ritter; Kaneko & Pettway; Kaneko	3,974	1970-2021	49.0%
Jordan	Al-Ali and Braik	53	1999-2008	149.0%
Malaysia	Isa; Isa & Yong; Yong; Ma; Dealogic	571	1980-2019	50.3%
Mauritius	Bundoo	40	1989-2005	15.2%
Mexico	Aggarwal, Leal & Hernandez; Eijgenhuijsen & van der Valk; Villarreal	149	1987-2017	9.9%

Country	Source	Sample Size	Time Period	Avg. Initial Return
Morocco	Alami Talbi; Hearn	33	2000-2011	33.3%
Netherlands	Wessels; Eijgenhuijsen & Buijs; Jenkinson, Ljungqvist, & Wilhelm; Dealogic	245	1983-2021	12.0%
New Zealand	Vos & Cheung; Camp & Munro; Alqahtani; Dealogic	277	1979-2022	15.5%
Nigeria	Ikoku; Achua; Dealogic	125	1989-2017	10.3%
Norway	Emilsen, Pedersen & Saettem; Liden; Dealogic; Fjesme	368	1984-2021	10.3%
Pakistan	Mumtaz	80	2000-2013	22.1%
Philippines	Sullivan & Unite; Dealogic	173	1987-2018	17.3%
Poland	Jelic & Briston; Woloszyn; Sieradzki	350	1991-2019	11.7%
Portugal	Almeida & Duque; Dealogic	33	1992-2017	11.5%
Qatar	Dealogic	17	2003-2021	257.2%
Russia	Dealogic	64	1999-2013	3.3%
Saudi Arabia	Al-Anazi, Forster, & Liu; Alqahtani; Dealogic	126	2003-2021	179.2%
Singapore	Lee, Taylor & Walter; Dawson; Dealogic	722	1973-2021	24.7%
South Africa	Page & Reyneke; Ali, Subrahmanyam & Gleason; Dealogic	342	1980-2018	17.2%
South Korea	Dhatt, Kim & Lim; Ihm; Choi & Heo; Mosharian & Ng; Cho; Joh; Dealogic; Lee	2,246	1980-2021	52.7%
Spain	Ansotegui & Fabregat; Alvarez Otera; Dealogic	204	1986-2021	9.5%
Sri Lanka	Samarakoon; Dealogic	134	1987-2018	28.9%
Sweden	Rydqvist; Schuster; de Ridder	442	1980-2021	28.2%
Switzerland	Kunz, Drobetz, Kammermann & Walchli; Dealogic	173	1983-2021	24.6%
Taiwan	Chen; Chiang	1,974	1980-2021	37.6%
Thailand	Wethyavivorn & Koo-smith; Lonkani & Tirapat; Ekkayokkaya and Pengniti; Vithessonthi; Dealogic	785	1987-2021	39.8%
Tunisia	Hearn, Dealogic	38	2001-2014	21.7%
Turkey	Kiymaz; Durukan; Ince; Kucukkocaoglu; Elma; Tanyeri, Ozturkkal, & Tirtiroglu	529	1990-2022	13.0%
United Arab Emirates	Alanzi & Al-Zoubi; Dealogic	35	2003-2021	186.4%
United Kingdom	Dimson; Vismara; Levis; Vismara; Doukas & Hoque; Khurshed	5,309	1959-2020	15.7%
United States	Ibbotson, Sindelar & Ritter; Ritter	13,757	1960-2022	17.5%
Vietnam	Tran, Le & Hoang; Nguyen, Trinh, & Ninh	167	2005-2017	33.3%

Table 17
List of PE and VC-sponsored companies listed on Norwegian exchanges 2010-2020

Company	Ticker	Date of listing
Bridge Energy ASA	BRIDGE	21/05/2010
KMCP	KMCP	06/07/2010
Cellcura ASA	CELLC	06/10/2010
Asetek	ASETEK	20/03/2013
MultiClient Geophysical	MCG	02/05/2013
NAPATECH	NAPA	06/12/2013
Zalaris	ZAL	20/06/2014
XXL	XXL	03/10/2014
RenoNorden	RENO	16/12/2014
Nordic Nanovector	NANO	23/03/2015
Europris	EPR	19/06/2015
BerGenBio	BGBIO	07/04/2017
Saferoad Holding	SAFE	29/05/2017
EVRY	EVRY	21/06/2017
Infront	INFRNT	29/09/2017
Webstep	WSTEP	11/10/2017
Crayon Group Holding	CRAYON	08/11/2017
poLight	PLT	01/10/2018
OKEA	OKEA	18/06/2019
Kahoot!	KAHOT	10/10/2019
SATS	SATS	23/10/2019
Exact Therapeutics	EXTX	14/07/2020
BEWi Group	BEWI	29/08/2020
Mintra Trainingportal (Mintra Holding)	MNTR	05/10/2020
Vaccibody (Nykode Therapeutics)	VACC(NYKD)	07/10/2020
Play Magnus	PMG	08/10/2020
CSAM Health	CSAM	09/10/2020
Link Mobility Group Holding	LINK	21/10/2020
Cyviz	CYVIZ	16/12/2020
Elektroimportøren	ELIMP	16/12/2020
Skitude Holding (Canopy Holding)	CAN	18/12/2020