Venture Capital and Innovation impact on Initial Public Offerings in United Kingdom

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Dissertation

Master in Finance

Supervised by

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2018

Acknowledgments

Hereby, I have some acknowledgments to make. First, I have to deeply thank my supervisor, Miguel Sousa, for his recommendations and advices. Second, I would like to thank my family for the support throughout this whole year. Third, I would like to thank Filipa for the long hours of work, patience and motivation which indeed helped me to achieve my goals. Fourth, I would like to thank my friends Pedro and Bruno for their helpful and supportive advices. Last, but not least, I want to thank all my friends that, throughout this journey, gave me pleasant words of motivation. I also want to apologize everyone for the times where space and focus were needed. I bear in mind that, without all of you, this piece of work could not have been done in the way it was. Thank you for accompanying me on this journey.

Abstract

Venture capitalists usually invest in technologic, young and growth companies and frequently lead them to an initial public offering, where they tend to liquidate their investments using the going public process as an exit route. We investigate the impact of such investments in one of the biggest IPO anomalies, the underpricing. Additionally, we also test if the industries known to be technologically intensive suffer from greater underpricing. We conduct our investigation using a sample of 639 IPOs in the United Kingdom between 2004 and 2016. Following the lack of the high technological industry significance to explain underpricing in past studies, we could not find any evidence of explicative power of those specific industries. Contrary to most of the literature on the venture capital backed IPOs, we found evidence that the venture capital backed issues are more underpriced than the remaining issues. To address that interesting outcome, we test the hypothesis that the greater underpricing results from the investors' expectation of a better operating performance in the post-IPO period provided by the venture capitalists specialization. In fact, using a matching-firm methodology, we found that the venture capital backed companies present better operating performance, at least, 3 years after the IPO.

Keywords: Innovation, Venture Capital, Initial Public Offerings, Underpricing, Operating Performance

JEL-Codes: G10, G11, G24, G34

Resumo

Venture capitalistas investem, normalmente, em empresas jovens, tecnológicas e com grande potencial de crescimento que frequentemente acabam numa oferta pública inicial (IPO), onde eles optam, tendencialmente, por liquidar os seus investimentos usando o este processo como uma saída para os seus investimentos. Investigamos o impacto desse financiamento num dos maiores puzzles dos IPOs, o underpricing. Adicionalmente, também testamos se a indústrias mais intensivas em tecnologia sofrem de mais underpricing durante a oferta pública inicial. Na nossa investigação, usamos uma amostra de 639 IPOs no Reino Unido entre 2004 e 2016. Tal como em anteriores estudos, não conseguimos obter nenhuma significância relevante relativamente às indústrias intensivas em tecnologia. No entanto, ao contrário da maioria da literatura, nós verificamos que as ofertas apoiadas por venture capital têm mais underpricing. Para analisar estes resultados, testamos a hipótese de que maior underpricing advém de uma expectativa futura dos investidores de uma melhor performance operacional depois do IPO devido à especialização dos venture capitalistas. Usando uma metodologia de correspondência entre empresas, encontramos resultados significantes de que as empresas apoiadas por venture capitalistas apresentam menor underperformance operacional, até 3 anos depois do IPO.

Palavras-chave: Inovação, Venture Capital, Ofertas Públicas Iniciais, Underpricing, Performance Operacional

JEL-Codes: G10, G11, G24, G34

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1. Introduction

The Venture Capital industry has been increasing its importance in the financial field and its impacts in the investee firms. The value created in the years following the investments is overall well-accepted in the literature but the conclusions around what causes that value creation are still very dispersed. Moving away from the academic perspective, it is also possible to recognize the impact of venture capital in the firms that surround us in our daily lives. Some of the largest firms nowadays were finance by a venture capital firm in their beginnings, which can arguably be an important factor for the success of those firms, because they had an early access to capital and knowledge provided by the venture capitalists.

Innovation, on the other hand, is what fuels the development of economies, in a macroeconomic level and firms in a microeconomic perspective. In the past decades the importance of innovation has been increasing unprecedentedly with managers being more active in their search for new ideas and investors being more aware about what firms are working harder seeking innovation. However, even though innovation, undoubtedly, has value, its true value is hardly recognized by outside economic agents due to the need of the innovation market to be not transparent or the firms might lose their competitive advantage obtained by the innovation itself. This incident, based on the information asymmetry phenomenon, attracts several researchers to dig into the topic finding unclear conclusions relative to positive and negative effects of the innovation between firms and outside investors.

Innovation is a very much relevant part of business, moreover in the industries where venture capitalists focuses their investments more. By crowding both areas together, venture capital and innovation, and focusing in the IPO market, the literature becomes even more interesting. The impacts of these variables in their respective firms, positive or negative, is undeniable. Several researchers studied such effects in diverse manners obtaining, sometimes, significant results. Knowing the plausible relation of venture capital and innovation and its implication on the IPO market, we decided to center the attentions of our study in one of the biggest IPO puzzles, the underpricing. Based on past studies, we expect a significant negative relation between the underpricing and venture capital, as we will try to find any significance regarding the innovation relation with the underpricing.

The geographical focus of this research is the United Kingdom and the market studied is the London Stock Exchange. The choice of this regions is founded in the gap in current literature regarding this particular market since there are not relevant researches studying

these specific relations in the IPO market, especially in the last years. Other reason for me to find it worth to study this topic is also to analyze the impact of the financial crisis that devastated Europe, which takes part of the study period (2004 – 2016). Furthermore, we find those topics relevant to the current literature due to the conclusions' divergence among researchers and our goal is take our own conclusions regarding the UK market.

The structure of this study proceeds as follows. In the next section the literature on the topic is revised. In section 3, the data and methodology used are described. Section 4 is used to describe our sample. Our regression results are presented in section 5. The section 6 analyse the post-IPO operating performance. In the section 7, we present our conclusions.

2. Literature Review

The Initial Public Offering – IPO - happens when a firm sells its stock to the public for the first time. Fama and French (2004) argue that the IPO "*is the point of entry that gives firms expanded access to equity capital, allowing them to emerge and grow*".

Researchers have studied several potential variables influencing IPO such as venture capital (Barry et al., 1990; Megginson and Weiss, 1991), innovation (Guo et al., 2006; Heeley et al., 2007), underwriter reputation (Carter and Manaster, 1990; Carter et al., 1998), firm size (Ibbotson et al., 1988), firm age (Megginson and Weiss, 1991; Mikkelson et al., 1997; Ritter, 1991), investor sentiment (Derrien, 2005; Ljungqvist et al., 2006), level of CEO ownership (Certo et al., 2003), top management legitimacy (Cohen and Dean, 2005) and media attention (Pollock and Rindova, 2003).

For the case of venture capital backing and underwriter reputation, it sends a positive message to investors. In some other cases, the investors might look for firm-level information using proxies such as firm size or age to signal how viable the firm could be.

Knowing that investors don't have full information about the firms, firms and underwriters intentionally underprice the issue to incentive investors to take part on the IPO. Higher levels of information asymmetry between firms and investors will require a higher discount in the offer price to create bigger incentives to investors (Rock, 1986).

The underpricing of IPOs is a known phenomenon being caused, most of the times, by information asymmetry and investors' wrong evaluations, say the financial scholars. To explain the first, there have been developed various theories mentioning the information asymmetry between the IPO participants as the cause of that phenomenon. Baron (1982) assumed in his model that the agent, the underwriter, has more knowledge about market conditions and investors than the principle, the IPO issuer, which is consistent with the book-building and adverse selection models that assume that the IPO issuer is indeed less aware about market conditions than the IPO investors (Benveniste and Spindt, 1989; Rock, 1986). On the other hand, underpricing signaling models are constructed based on the assumption that the issuer has greater knowledge about its own firm than outside investor (Allen and Faulhaber, 1989), generating a discordance among authors.

To explain the cause of underpricing many studies have been conducted, however, most of the times, the source of information asymmetry is not acknowledgeable and some

proxies are used to relate underpricing and information asymmetry[1] preventing clear conclusions about the topic (Guo et al., 2006). Instead of depending on noisy proxies, it would be of rather importance to find the origin of such information asymmetry, since it would be helpful to guide investors, managers and regulators to diminish that asymmetry and improve of market efficiency.

Throughout the years, many researchers have developed some theories to explain the underpricing. Even though it is an extensive list of theories, we found relevant to sum up some of the most relevant theories developed yet. Ljungqvist (2005) grouped the underpricing theories between asymmetric information, ownership and control, institutional reasons and behavior approaches. The asymmetric information problems arise when one of the three parties in the IPO process – the issuer, the underwriter and the investors – is more or less informed in relation to the other parties. The winner's curse model of Rock (1986) assumes the presence of informed and uninformed investors in the market, where only the uninformed investors will trade in an overpriced IPO. Since the issuing firm rely on the capital from both type of investors, they underprice the issue to keep both interested in the issue. Based on the signaling theory, issuers underprice the IPO to signal the quality of their firms' prospects. Allen and Faulhaber (1989) defend that the firms has greater knowledge about its future, so the firm leaves money on the table at the time of the IPO because they know they have the ability to recover that money in a posterior seasoned offering. Argument that fails in low-quality firms since that ability is not present due to lower quality prospects. The market feedback hypothesis is based on the idea that institutional investors have more information about the market conditions of the issuing firms and to obtain such information, Ritter (1998) defends that the issuing firm and the underwriter lower the offer price to compensate that institutional investors.

The ownership and control theories defend two opposite point of views. After going public, the ownership of the firm is split among several group of investors which can lead to agency costs. Brennan and Franks (1997) defend that underpricing comes due to an oversubscription of shares in the IPO. They argue that firms prefer a less amount of shares allocated among diverse investors since the managers are more protected from the shareholders analysis and from hostile takeovers. On the other hand, Stoughton and Zechner (1998) defend that a higher allocation of shares add value due to monitoring reasons, since large institutions are more able to highly monitor the firm and reduce agency costs.

[1] Proxies such as retained ownership, firm size or underwriter reputation.

The institutional reasons come from the litigation risk. The underwriters intentionally underpricing to avoid the risk of being sued by the investors in a case of a loss at the IPO.

Regarding the behavioral approaches that more recently appeared, the behavioral finance believes in the influence of irrational investors on stock prices. Thus, the issuing firms will want to profit from the positive sentiment in the market related to them and to do so, they rely on the institutional investors to hold the shares for a period of time and intentionally underprice the issue to compensate them (Ljungqvist, 2005). Finally, based on the prospect theory, Loughran and Ritter (2002) defend that the issuers do not mind to bear the cost of the underpricing because value more the change in their wealth than on the level of their wealth. Ultimately, the issuers, as decision markers, are happy with the underwriter's behavior if the acknowledgeable wealth gain is superior to the underpricing cost (Loughran and Ritter, 2002).

Since we are now more aware of the underpricing theories, it is important to switch to the core of our study. Theoretically speaking, some of the value created by venture capitalists comes through in the form of reduced information asymmetry due to their certification power. Contrarily to this effect, the firms' innovation might increase that asymmetry between insiders and outsiders due to it being an opaque market. Being the focus of this study, these two factors are analyzed in the following sub-sections.

2.1. Venture Capital

Venture capitalists are professional investors that invest on behalf of their partnership funds. They usually are informed investors that observe every aspect of the markets of their choice, mostly technological markets, to make better decisions for their projects (Fenn et al., 1995). Venture capitalists invest in private companies unknown to the common public, being startups and growing firms their main focus since these are the most prone to have asymmetric information and capital constraints, problems which venture capitalist helps solving. However, they only invest in a small number of firms out of the group they decide to evaluate. To find, theoretically, the firms who will perform superiorly, venture capitalists do a screening analysis which allows them to efficiently discover the best firms to invest. Therefore, when a firm backed by venture capital decides to go through an IPO, it is expected that the firm is already properly screened and financed, that the management team and the

board of directors[2] has been selected cautiously and in place, the prospects of the firm are promising and that there are positive market contacts benefiting the firm.

Venture capitalists can help the firm lowering the asymmetric information between the firm and potential investors, mainly institutional[3], affecting who publicly hold the firm after the IPO[4] due to their top-tier contacts. Thanks to the venture capitalists' capital, these firms are less dependent on internal growth and cash flows.

Yet, the venture capital industry relies on an efficient IPO market to properly function. A powerful IPO market will promote a healthier venture capital industry since the most of venture capital firms' profit comes from the initial public offering on the IPO market (Gompers and Lerner, 1997)[5] which is used as an exit route for their investments[6]. The IPO exit strategy is the most successful and profitable to its investors out of all venture capitalists' exit strategies (Lerner and Gompers, 1999). Therefore, a strong IPO market will allow them to execute a better distribution of their assets in future projects, after the previous project has entered the public market, as well as raising further capital due to having a reputation of being able to take firms public (Gompers, 1996). To understand the relevance of the venture capital industry in the IPO market, Sahlman (1990) showed that one third of the companies entering the public market are backed by a venture capital fund and Jain and Kini (1999a) found that also one third out of the issuing firms are acquired or fail in their first five years after the IPO. The venture capital investments also seem to have an impact on how fast the firms reach the public market, since their prioritize their investments in younger companies and accelerate their IPO process with their greater expertise and contacts, so that it is doubtful that a non-VC-backed firm would be ready to handle an IPO before their counterparts do (Jain and Kini, 2000). Furthermore, Black and Gilson (1998) found a strong

[2] Prior research indicate that venture capitalists are often involved in their portfolio firms' management and board of directors, combining that with strong equity positions, providing them with significant ownership and economic rights (Barry et al., 1990; Megginson and Weiss, 1991; Sahlman, 1990).

[3] Institutional investors are the source of venture capital firms and they will often hold equity in firms where venture capitalists have invested

[4] Higher institutional holdings mean that the price is less influence by investor sentiment and behavioural theories argue that investors weight recent results too heavily

[5] Lerner and Gompers (1999) showed that the IPO exit strategy is the most successful and profitable to its investors out of all venture capitalists' exit strategies.

[6] Barry et al. (1990) showed in their sample that most of the capital invested by venture capitalists is hold after the IPO.

a correlation between the number of IPO firms' backed by venture capital and successive commitments to venture funds afterwards.

2.1.1. Venture Capitalists Duties

When in the prospect of an IPO there is information that the firm has been backed by venture capital, institutional investors immediately assume that the firm has been properly screened and monitored, being a credible signal given by venture capitalists that the firm has good prospects of growing, duly financed and, most likely, ready to enter in the public market (Jain and Kini, 2000). Additionally, with the venture capitalists' reputation capital at stake, the relationship quality between institutional investors and venture capitalists is improved since the venture capitalists have little to no incentives to hype a stock or overprice it (Brav and Gompers, 1997). During the road-show, firms in the portfolio of venture capitalists attract higher quality institutional investors in comparison to non-venture capital backed firms, improving the chances of survival of IPO issuers (Jain and Kini, 2000).

The venture capitalists also perform monitoring duties in their firms before and after the IPO. Venture capitalists provide high monitoring[7] to their firms' management to obtain a strong growth before the IPO to get the higher offer price possible at the IPO, since it is a very reasonable exit strategy, allowing them to redistribute their skills in other early growing firms to continue their activity. However, if they keep part of their stakes after the IPO, they will want to assure a sustainable growth even after the IPO, thus it is necessary to continue with their monitoring responsibilities. First, venture capitalists understand that the market will understand their incentives to exit at the IPO, believing they would try to get the highest offer price possible, so the market accounts for that by discounting the price. Second, it was suggested by the *Venture Capital Journal*[8] that venture capitalists get most of their profits in the aftermarket when they keep their holdings, so maintaining their equity after the IPO might be of their best interests[9]. The third reason for venture capitalists to continue their

[7] Venture capitalists constantly monitor their firms, formally, at the board level and informally (Lerner, 1995; Rosenstein, 1988).

[8] Venture Capital Journal, march, 1983

[9] Barry et al. (1990) report that venture capitalists hold 34% of their equity prior to the IPO and that 58% of venture capitalist didn't sell a single share at the IPO and continue to have a strong presence in the board of director post-IPO.

monitoring after the IPO is due to reputational concerns[10]. The venture capital industry is a small community, so the performance of each venture capital firm is observed closely (Sahlman, 1990). So, keeping the monitoring of the firms in their portfolio ensures they are doing well, allowing venture capitalists to be well-known and recommended to the various analysts, underwriters and investors in the IPO market, since past success is a really valuable selling point in this industry.

Regarding the information asymmetry problem, most of the times the certification done from someone outside of the company has value, value that comes from the potential elimination of information asymmetries related to the firms' value between insiders of the firm issuing shares and the outside investors (James, 1987; Puri, 1996, 1999). On the one hand, the insiders avoid or delay the disclosure of negative information to be able to sell their securities at a price higher than they should. On the other hand, the outside investors are aware of such strategies and discount their offerings to match the possibility of adverse information that has not been revealed yet. That suspicion could be almost fully erased if there is a third-party, such as venture capitalists, certifying the value of the firm. However, for the third-party certification to be believable they must have something to lose and be affected if the assessment of the value of the firm is wrong. To ensure the validity of such certification, the third-party must have reputational concerns that would be affected in the case of a false certification, which a venture capitalist does[11], the value of the third party's reputational capital at risk must overcome the payoff of not certifying correctly, which a venture capitalist does (Sahlman, 1990)[12], and it must be very costly, economically and in difficulty, for a firm to acquire the same type of services that a third party-agent provide, which it is[13].

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[10]Gompers (1996) saw that reputation concerns affect the decision made by venture capitalist when they take firms public because if they fail in the public market, the future firms will not trust them so easily to bring the firm public. So, with that in mind, venture capitalist will not be willing to hype or overprice a stock.

[11] Venture capitalists have the incentive to create and maintain a good a trustworthy reputation with other IPO participants to ensure access to the market with more favorable terms. The higher the reputation, the higher the attractiveness to entrepreneurs and investors, which is crucial to ensure continuous agreements and interest in the firms' shares.

[12] Venture capitalists can get very high payoffs on relatively small capital investments, which is related to the age and historical performance of the venture fund. The venture capital management market is really small and individual performance is closely observed so, investments in reputational capital allow them to keep being competitive in the industry (Sahlman, 1990).

[13] Venture capitalist pass this test since the services they provide, such as capital, experience, connections in the market and technical and management expertise are very hardly obtained.

Venture capitalists play in the IPO market repeated times allowing them to stablish long-term relations with many other IPO market participants, have higher reputation underwriters, present better analyst coverage, affect institutional investors and present bigger levels of R&D expenditures (Brav and Gompers, 1997; Jain and Kini, 2000). Those kinds of relations provide positive impacts on the equity price of the firms where venture capitalists invest, meaning that they can obtain a higher price for their equity than would a firm without venture capital[14]. The possibility of getting a higher price due to better relations with higher quality IPO market participants[15] was called by Chemmanur and Loutskina (2006) the market power of venture capital. Megginson and Weiss (1991) also supported the idea that venture capitalists get their firms better connections in the IPO market, higher quality underwriters, auditors, analysts and are viewed by the investors as more attractive to invest than other firms without venture capital backing.

However, there is a paradox between the certification and market power value of venture capital, since they have different concepts. The first defends that venture capital backed firms will price their equity closer to their intrinsic value to maintain their reputation with IPO market's investors. On the other hand, the market power concept is more concerned with their reputation related with their venture fund's investors and entrepreneurs, where their goal is to get the highest price possible for their equity stake at the IPO to make their funds' investors happy with higher returns.

2.1.2. Underpricing

Concerning the underpricing phenomenon, the impact of the venture capitalists in the IPO process has been deeply studied. The IPO underpricing is the difference between first-day closing price and the IPO offer price, the underpricing is considered to be money left on the table by the firms, however it is mostly inevitable.

Having in mind the impacts of venture capital in their firms and in the IPO market, by influencing the offer price at which their firms go public, they affect the underpricing. Megginson and Weiss (1991) showed that the IPO proceeds are maximized with the presence

[14] Many researches such as Carter and Manaster (1990), Carter et al. (1998) and Jain and Kini (1999b) showed that more prestigious investment bankers obtain better results in the offer price setting and long-term IPO performance.

[15] The basic idea behind that argument is that backing an IPO with better quality participants will give a positive sentiment to the retail investors making them more optimistic about the firm, allowing the company to issue at a higher price.

of a venture capital investment in the issuing firm, while their presence also reducing the mean and median of underpricing, thus reducing the spread requested by the underwriter. Chemmanur and Loutskina (2006) found that venture capital backed IPO's presented less underpricing than their counterparts, being that difference attributed to the venture capital certification[16]. Barry et al. (1990) also found the same result but they pointed out venture capital screening[17] and monitoring (both hypothesis reach the same conclusion: venture capital backed firms are of better quality than non-venture capital backed[18]) as the cause of such difference. However, these results are not universal. Lee and Wahal (2004) and Loughran and Ritter (2004) obtained different results where the IPO's of venture capital backed firms had more underpricing than firms without such financing.

Although underpricing is very much studied in the IPO's literature, using the underpricing as a measure in any study related to venture capital implies strong and powerful assumptions. First, it is assumed that the first day closing price of the firms' stock is equal to its intrinsic value. Second, it is also assumed that venture backing does not affect the stock price at the end of the first day in the secondary market. If, for instance, venture capital impacts both the offer price of an IPO and its first day closing price, we cannot consider the underpricing as a meaningful measure of the economic implications of venture capital since it only values the difference between both values which can both differ from its intrinsic value.

2.1.3. The post-IPO

However, the value added by the venture capitalist is not limited to the pre-IPO stage and at the first issuing day and the literature also tested the impacts on the firms' operating performance years after IPO. Venture capital backed firms' IPO outperform non-venture

[16] Venture Capital Certification is related with reputation concerns. Venture capitalist are consistently playing in the IPO market, so they try to price their equity in the IPO's close to their intrinsic value to keep their reputation at high levels. Reputations is of important matter for the venture capitalist because it allows them to maintain a secure and credible position in the market. To Gompers and Lerner (1999) the venture capitalists' reputation is crucial for their ability to raise money to finance the following venture funds.

[17] Venture capitalists only invest in a small minority of firms meaning that those firms where they invest are recognized as having higher quality than non-VC-backed firms. This is known as Venture Capital Screening.

[18] However, Allen and Faulhaber (1989) and Chemmanur (1993) reached a different conclusion. In their studies, the higher quality firms proved to be more underpricing than lower quality firms.

capital backed firms' IPO during a five years period[19] and that underperformance of non-venture backed firms is driven primarily by small issuers[20] (Brav and Gompers, 1997), however Fama and French (1996) with their three-factor model could not explain the underperformance of these small non-venture capital backed issuers.

Venture capitalists, due to their repeated transactions, reputation capital and, most of the times, board participation in the firms they invest in, have the knowledge and capacity to impact the management actions regarding strategies, structures and operating procedures so that they provide a useful support for their firms pre and post-IPO, increasing the survival probability after going public.

Venture capital investments focus majorly on risky technological companies where, since they are risky, the chance of the investment being a failure is quite high, thus venture capitalists can contribute to the process of going public by raising the survival rate of the IPO issuers. Since there is a specialization by venture capital in such technological companies, their managers should be better prepared to face the difficulties pointed by Singh (1997) which is that high failure rate in technological markets are cause by the high organizational costs of commercializing such products and the difficulties related to the managers' capabilities to develop a company in that market. Indeed, Jain and Kini (2000) found that the presence of venture capitalists at the IPO improve the chance of survival of the issuing firm and that it is more probable that a venture capital backed firm will survive longer than a specific time than a non-venture capital backed firm.

To summarize the value creation by venture capitalists let's look at the expected effects on the market. If venture capitalists make their portfolio firms better than the others, an efficient market should incorporate these expectation in the offering price and the long-run performance should be similar. If the market indeed underestimates the venture capital importance, the long run performance of both types of firms should differ, not only because the venture capitalist might really provide value, but also because individuals investors hold a larger fraction of stake after the IPO in non-venture capital firms.

If venture capitalists reliably affect the offer price, it is expected that the underpricing presented by non-venture backed firms is higher than the underpricing of venture capital backed firms.

[19] When returns are weighted equally.

[20] Market Capitalization under £ 50 Million.

If the constant monitoring before and after the IPO brings any value to the company, it is expected that venture capital backed firms operationally outperform issuers that were not backed by venture capital.

Venture capitalists focus only in some industries allowing them to have a strong knowledge and expertise about the industry and have powerful contacts in the area to bring better employees, suppliers and customers to the firm (Bygrave and Timmons, 1992; Warne, 1988). If any of these connections related to venture capital has any value, it is expected that firms backed by venture capital outperform similar non-venture capital backed firms after IPO.

2.2. Innovation

Research and development (R&D) was defined by Guo et al. (2006) as possibly the most important contributor to IPO uncertainty based on technology and science-based issues. The information related to R&D has to be disclosed separately in financial reports by firms contrasting with other intangible investments that are often aggregated together, facilitating the research, this being the reason for R&D to be the most researched intangible investment in economics and finance. Past relevant studies concerning R&D bring up two interesting phenomena. First, Aboody and Lev (2000), showed that R&D intensive firms' insiders, namely managers and large holders, profit significantly more by trading their firms' stock than insiders of low R&D firms. The second phenomenon is based in many studies (Chan et al., 2001; Eberhart et al., 2004; Lev and Sougiannis, 1996; Penman and Zhang, 2002) which defend that R&D intensive firms are undervalued by investors.

2.2.1. Firm value and IPO underpricing

There is a positive relation between innovation and firm value (Griliches, 1991; Pakes, 1985), however their impact on IPO is not so clear and it has been suggested by Guo et al. (2006) that R&D investments are positively related with IPO underpricing. With that being said, it seems we are in the presence of a paradox. Prior to the IPO, investments in R&D could result in a large underpricing, due to lower offer prices resulted from uncertainty and more money left on the table. After the IPO, the same type of investment increases the firm value.

R&D investments, ultimately result in a patent, which is a more palpable assessment of innovation. The act of patenting an idea is, most of the times, associated with the need of a firm to protect an idea or technology or to hinder the entrance of a competitor in its market. However, Rock (1986) argued that the reason behind the decision to patent, specifically if it leaks information about the firm's value, might be a strategy to obtain a high offer price due to the lower information asymmetry. Furthermore, by increasing and R&D and innovation activities, a firm also increases the amount of information needed for an investor to assess the value of those investments, meaning that intensive R&D firms suffer from greater information asymmetry between insiders of the firm and its investors than a low R&D firm. So, it is expected that insiders would be able to obtain larger returns than uninformed investors in high R&D firms, proving that they were able to better assess the value of the firm than other common investors like it was demonstrated by Aboody and Lev (2000).

Guo et al. (2006) results[21] suggested that companies which disclose more about their R&D investments suffered less from IPO underpricing than the others, attributing the reason of the lower underpricing to transparency[22]. The first day underpricing is strong and positively influenced by the intensity of R&D of the issuer pre-IPO, being the underpricing of R&D intensive firms almost two times the underpricing of no R&D firms, meaning that R&D is a very important regressor to explain the first day underpricing, even more significant than underwriter reputation and venture capital backing, which were important variables in past studies (Guo et al., 2006).

Studies show that in seasoned stocks, the investors fail to recognize the R&D benefits to its full potential, most likely due to information asymmetry (Chan et al., 2001; Eberhart et al., 2004). Since the investors' optimism at the IPO is mitigated by their underreaction to R&D benefits, it is expected that highly intensive R&D firms in the long run will suffer from less underperformance than no-R&D firms[23], and Guo et al. (2006) reached that exact conclusion that high R&D firms outperform low R&D firms that also outperform no-R&D

[21] Guo et al. (2006) compared pharmaceutical and biotech companies which disclose uniformly the nature of their R&D expenses with other high R&D industries who disclose less information about their R&D activities and compared their underpricing.

[22] In a high-transparency (low) context, promoted by less (more) information asymmetry, underpricing is reduced (higher) when patenting increases (decreases).

[23] Since the investors are slow to understand the benefits of R&D activities they will lower their expectations believing it is risky to be dependent on the success of such activities. Overall, the investors had much more optimism about the no-R&D IPOs than the intensive R&D IPOs.

firms and found a strategy that yields a significant return[24]. It was also documented in their study that the long run (three years after the IPO) underperformance is an event that seems to happen only in no-R&D firms.

The R&D intensive firms don't mind that the investors lower their expectations because they expect to recover the money left on the table at the IPO after they cash-in their R&D investments. To support this hypothesis, Guo et al. (2006) found that intensive R&D firms earn more from their seasoned stock offerings than low or no-R&D firms. Furthermore, their model proved to be a strong predictor of the initial underpricing and the long run performance of the IPOs.

However, R&D is an input to innovation and not the output, to address the R&D and underpricing relation, Griliches (1991) used information about the patents statistics as the innovation output. Heeley et al. (2007) showed that patents have the potential to leak some information about the value of the firm related to innovation activities at the IPO, but the relation with underpricing will rely on the transparency between patenting and value appropriation.

Using a different approach to innovation, Loughran and Ritter (2004) separated industries between technological and non-technological related industries, based on the idea that technological companies bear greater risk due to technological and valuation uncertainty. Technological firms are likely to be younger and thus smaller firms, increasing even more the risk of such stocks. Loughran and Ritter (2004) found that tech IPOs suffer from greater underpricing that non-tech IPOs. Bomans (2009) achieved the same results and attributed that underpricing level difference to the unpredictability of those stocks, many technological firms are able to emerge and grow, but only a few survive. Unpredictability that increases due to value assessment difficulties of technological products in comparison with other more tangible products which are easier to evaluate (Bomans, 2009). Contradicting those findings, Beck (2017), using the same industry division as Loughran and Ritter (2004) did, could not find any statistical underpricing difference within industries, tech or non-tech. Karlis (2008) evidenced that companies using internet as their primary line of business are more underpriced, which is line with the theories previously mentioned.

Both ways to assess innovation, using R&D expenditures and industry filtering, are based on the same premise: the technological-related IPOs are riskier and face more uncertainty and are expected to suffer from greater underpricing levels. Since the

[24] The strategy is to invest in high-R&D (or low-R&D) IPOs and go short on no-R&D IPOs, generating gains of 9% annually during three years after the IPO.

confidentiality is characteristic of the innovation market, we had limited access to the companies' research and development expenses. Therefore, our study is conducted using the industry filtering method to assess the power of innovation on the underpricing.

2.3. Innovation and Venture Capital

Considering both the venture capital industry and the technological industry together, it is also possible to see a correlation between them. By being financed by venture capital the firms are able to reduce the time in pursuing innovation (Hellmann and Puri, 2000) and by doubling the number of companies financed by venture capital in a certain industry will increase the number of patent applications by 5 to 18% (Kortum and Lerner, 1998). So, a firm by spending more than the average on R&D can be used as a proxy to show their focus in pursuing innovation. With that being said, firms backed by venture capital are expected to spend more money in R&D and to have a greater focus on the technological market than their counterparts in their industry and, obviously, have more success in spurring innovation. (Jain and Kini, 2000).

Consistent with the increasing R&D of venture capital backed firms, the number of patented innovations is also influenced by venture capital financing. The presence of venture capital improves substantially the patenting, where a dollar of venture capital stimulates patenting three times more than does a dollar of traditional R&D (Kortum and Lerner, 1998).

However, venture capital might increase patenting but having little or no impact on innovation[25], but Kortum and Lerner (1998) found that venture capital firms' patents are more cited than the others and there is no evidence that venture capitalists patents are of lower quality. Much have been discussed about the relation between patenting and innovation or, in this case, the relation between venture capital and patenting that could not imply the same type of relation between venture capital and innovation[26]. Kortum and Lerner (1998) pointed out two major reasons for venture capital backed firms to patent innovations that other type of firms would not be eager to patent. First, it is due to external appropriation concerns. They suspect that venture capitalists, with their insight on the firms' operations might use their ideas and procedures and transmit them to other similar firms in future

[25] If, for instance, venture capital backed firms only patent more their innovations to impress investors, that will have no impact on innovation.

[26] For example, the increase in patenting could be a consequence of an adjustment in the propensity to patent innovations motivated by the venture capital financing itself (Kortum and Lerner, 1998)

projects. The second reason is related to firms' patenting value. The firms seeking for external financing will register patents on worthy technologies to raise their attractiveness.

Another arising questions is if the type of investor has an impact on the outcome of the product. Again, on the one hand, the venture capitalists might would shift the entrepreneurs focus to the key aspects of the strategy influencing the time it takes to bring the product to the market. On the other hand, they could also be more tolerant investors that with their financing give the firm more time to grow on their terms.

Hellmann and Puri (2000) findings suggested that innovators are more probable to be financed by venture capital than imitators and that imitators receive the financing earlier in their life stage. They also found that venture capital financing is significantly associated with faster time to market to innovators[27] which are more affected by the speed that they take to bring the product to the market.

[27] The faster speed to market is statistically insignificant to imitators.

3. Data and Methodology

The following section gives a brief description on how the IPO sample was gathered, the methodology employed in the research, the collection and the reasons behind the variables chosen. A descriptive statistic is also presented. All this, while naming some of the incongruities and setbacks of our approach.

3.1. Sample

Our list of IPO deals was obtained in the Bureau van Dijk's Zephyr database. In the 13 years period of our study (2004-2016), were collected 1465 IPOs[28], issued by United Kingdom's firms, in both London Stock Exchange and in Alternative Investment Market (AIM), a market referring to smaller and growing companies. In order to obtain a more informative sample, the Worldscope database was used to retrieve information about the offer price, the first day closing price, the market capitalization and other relevant operational data, while Eikon Thomson Reuters was used to get information on the offerings' underwriters[29]. Out of this sample, following most of the literature, were eliminated demerges, unit-offering, closed-end funds, REIT, Financial institutions, ADRs and utility firms, since these firms have, sometimes, specific regulations, which corresponded to 642 IPOs around 44% of our sample. IPOs with an offer price lower than 1£ or an issue size lower than 1 million £ were also eliminated. Finally, observations with crucial missing data[30] were also eliminated, resulting in a final sample of 639 IPOs[31].

[28] We include in our sample IPOs of companies that have posteriorly delisted, been acquired or have bankrupted. We include dead stocks to avoid suffering from IPO survival biases.

[29] When the underwriters were not found in the Eikon Thomson Reuters database, we recurred to the firms' IPO prospectus to get such information.

[30] We considered as crucial variables the IPO offer price, the first-day closing price, so that we could compute the underpricing, and the IPO offering size.

[31] We eliminated 28 demergers, a total of 614 IPOs regarding unit-offering, closed-end funds, REIT, Financial institutions, ADRs and utility firms, 65 IPOs with offer size lower than £ 1 million, 49 IPOs with offer prices lower than 1£ and 70 IPOs with important missing data.

3.2. Methodology

To empirically test our underpricing hypothesis, we follow an approach similar to Barry et al. (1990) and Megginson and Weiss (1991). The first showed that the market recognizes the value added by venture capitalists' monitoring resulting in a smaller underpricing, adding that companies backed by higher-quality venture capitalists are even less underpriced. The latter, also found value in venture capitalist presence at the time of the IPO by using a methodology that matches firms by industry and offering size, which can take the firms public at a younger age and a greater median book value of assets. Furthermore, Megginson and Weiss, showed that venture capitalists, by reducing the information asymmetry between the market players and the IPO issuing firm, are able to reduce the costs of going public and lower the underpricing. To address that issue, venture capital backed firms were compared to non-venture capital backed firms to test if there is a significant impact of such financing in the IPO underpricing, offering size, market capitalization, total assets, underwriter quality or the age at which the firm goes public.

Contrary to the venture capital, which has been widely studied as a hypothesis to explain underpricing, the innovation has been left out of the discussion. Even though it has been present in some relevant studies as (See Loughran and Ritter (2004), Bomans (2009)), innovation lacks a recent deeper analysis. Many researchers suggest that being in high-innovative industry contributes to information asymmetry between the firms and the market (Heeley et al., 2007), thus impacting the IPO underpricing. Some studies faced low-technologic industries against high-technologic industries with ambiguous results. Shortly after the dotcom bubble, Loughran and Ritter (2004) used a technological industry division to explain the underpricing. Following him Kim et al. (2008) showed the high-tech industry as a significant explanatory factor to underpricing, Karlis (2008) found evidence of greater underpricing in internet related stocks and Bomans (2009) found that technologic-related IPOs are significantly more underpriced, while Beck (2017) suggested otherwise. In our study, we attempt to show evidence of explanatory power of the innovation through a deeper analysis. To do so, a high-tech dummy is included in our regression while also testing its relationship with other control variables. Our definition of high-tech industry is also different from what was previously used in the literature, which is covered in the variable description section.

So, to address the underpricing phenomenon, we compute several Ordinary Least Squares (OLS) regressions using the underpricing as dependent variable. To better understand the power of our results, we introduce new variables as we develop more

complete models. Our final and most complete regression, excluding some interactive variables added, is the following:

$$Underpricing_i = \beta_0 + \beta_1 VC_i + \beta_2\, Tech_i + \beta_3\, Market\ Cap_i + \beta_4\, Age_i + \beta_5\, Aftermarket_i + \beta_6\, Marketvol_i + \beta_7\, Market_i + \beta_8\, Crisis_i + \beta_9\, Size_i + \beta_{10} Capret_i + \beta_{11} UWrep_i + \varepsilon_i$$

Where the underpricing is the first-day return, VC is a dummy variable that equals 1 if the company is backed by venture capital and 0 otherwise, Tech is a dummy variable that equals 1 if the company's industry SIC code classification belongs to a high-technologic industry and 0 otherwise, Market Cap is the logarithm of the market capitalization at the IPO, Age is the logarithm of 1 plus the age of the company, Aftermarket is the volatility of the daily returns of the stock from day 2 to day 20, Marketvol is the market monthly volatility of the daily returns in the IPO month, Market is a dummy variable that equals 1 if the company is listed in the London Stock Exchange (LSE) and 0 if is list on the Alternative Investment Market (AIM), Crisis is a dummy variable that equals 1 if the issue is made during the crisis period (2008-2011) and 0 otherwise, Size is the logarithm of the gross proceeds of the issue, the Capret is the capital retained by the issuers' original shareholders, and, finally, UWRep is the reputation of the issue's underwriter.

3.3. Variables collection

Underpricing

The underpricing, as our dependent variable, is obtained by calculating the first-day trading return that results by dividing the difference between the first-day closing price and the issue's offer price by the issue's offer price. Our data relative to prices, offer price and first-day closing price, were retrieved from the Thomson Reuters Worldscope. Therefore, following the main underpricing literature, underpricing results as follows:

$$Underpricing_i = \frac{First\ day\ closing\ price_i - Offer\ price_i}{Offer\ Price_i} * 100$$

Venture capital

One of the main purposes of our research is to check if venture capital has an impact in the IPO initial return. To identify the issues that are backed by venture capitalists, we used the Bureau van Dijk's Zephyr database. To address that impact in our OLS estimation, we created a dummy variable (VC). It is expected that the initial returns are lower for issues backed by venture capital ($VC = 1$) than for the remaining issues ($VC = 0$). Therefore, it is expected a significant and negative relation between the dummy variable (VC) and underpricing.

Innovation

To address the information asymmetry caused by innovation, which is theoretically bigger in high technologic industries, we created a dummy variable $(Tech)$. The information asymmetry is known to increase the underpricing is issues where that asymmetry is bigger because it bears more risk and has more informative costs to assess true information about the company. However, the dummy variable's coefficient sign of our OLS estimation is hard predict, since there are not a very clear and significant results among the literature. The industries classified as high technologic industries does not follow the common procedures. Usually, the literature classifies high technologic industries by following the Loughran and Ritter (2004), which employed a methodology based on the US market, however, in our research, we opt for a different approach, that we consider to be more updated to the current reality and more focused on the specific market which is the UK market. Our classification of high technologic industries is based on the KPMG (2015). The industries considered as high technologic $(Tech = 1)$ are presented in the Appendix I along with a clarification of the methodology used.

Some other variables have been proved to be significant explanatory variables of the underpricing. Therefore, to isolate the influence of our hypothesized variables, we need to control our OLS estimation for those variables that the literature found significant to explain the underpricing, which are explored now.

Market Capitalization

We also include the market capitalization at the time of the IPO to measure the firm size impact on the underpricing. The firms' market capitalization signals the quality of the company following the Allen and Faulhaber (1989) and Welch (1989) signaling hypothesis. It has been documented a positive relation between the underpricing and the market

capitalization of the firm (Carter et al., 1998; Ibbotson et al., 1988). Once again, the data was collected in the Thomson Reuters Worldscope database.

$$Market\ Cap_i = \log(Market\ Capitalization_i)$$

Age

As in Muscarella and Vetsuypens (1989), Megginson and Weiss (1991) and Ritter (1991), the age of the company is also incorporated in our estimation as a control variable. The data was retrieved from the Bureau van Dijk's Zephyr database and we define the age of the company as the difference of the IPO calendar year and the company's incorporation calendar year. It is expected that younger firms suffer from larger underpricing than mature firms due to larger information asymmetry issues regarding younger firms. Thus, we expect a negative relation between Age and Underpricing. The variable included in our OLS regression follows Ritter 1991 as is computed as follows:

$$Age_i = \log(1 + Age_i)$$

Aftermarket

Following the approach of Barry et al. (1990), we also include an aftermarket variable that accounts for the volatility of the daily stock returns after the IPO, specifically between the day 2 through day 20. With higher aftermarket volatility it is expected that that first-day return is also more volatile, thus, we expect a positive relation between underpricing and the aftermarket standard deviation. The aftermarket prices were retrieved from the Thomson Reuters Worldscope database. In our estimation, to ease our interpretation, this variable is logarithmic.

$$Aftermarket = \log(returns'\ volatility\ from\ day\ 2\ through\ day\ 20)$$

Market volatility

In more unstable times or markets, it is expected greater underpricing. To account for that instability, we introduce a monthly market volatility. To construct this variable, we collected the FTSE All Share and FTSE AIM All Share Index's daily prices and computed the monthly standard deviation of the returns. The monthly volatility allocated to each IPO is market adjusted, meaning that to LSE issues, FTSE All Shares Index monthly volatility is

inputted and to AIM issues, FTSE AIM All Shares Index monthly volatility is inputted. Again, to easy our interpretation, this variable is logarithmic.

$$Marketvol = \log(Market\ Index\ Monthly\ volatility)$$

Market and Crisis

To control for other external sources of underpricing, we included two dummies relative to the market and timing of the issue, Market and Crisis. The issues in our sample are comprised between two markets, the London Stock Exchange main market and the Alternative Investment Market. Being in one or another market might influence the perspective of the investor about the issue and to address that we created a dummy that equals one if the issue was listed in the London Stock Exchange main market $(Market = 1)$. Moreover, during the time span of our study, the world faced a massive financial crisis that could have affected the investors behavior, thus, influencing the underpricing during that period. We have considered the crisis years to be between 2008 and 2011, inclusive. Therefore, our Crisis dummy variable is equal to 1 when the IPO is issued in those years.

Issue size

Ritter (1984) and Beatty and Ritter (1986) found evidence of the issue size impacting the underpricing, meaning that higher uncertainty allocated to smaller issues bear a greater underpricing. To address the issue size, we gathered the data in the Bureau van Dijk's Zephyr database.

$$Issue\ size_i = \log(Gross\ Proceeds)$$

Capital Retained

Retaining little or no equity stakes at the time of the IPO sends a negative signal to the market. If the shareholders are willing to sell huge amounts of equity at the IPO, that means that they are not confident about the future prospects of the firm, otherwise they would want to retain a bigger stake of the shares to profit in the future of such good prospects (Keasey and McGuinness, 1992). Higher levels of capital retained also reduce the agency costs (Jensen and Meckling, 1976). Therefore, we expect that IPOs with higher levels of capital retained suffer from less underpricing. Data retrieved from the Bureau van Dijk's Zephyr database.

Underwriter reputation

The underwriters also play an important role in the IPO market, where IPO issued by higher quality underwriters usually present less underpricing (see Barry et al. (1990), Megginson and Weiss (1991) Loughran and Ritter (2004)). To measure the quality of the underwriter, an underwriter reputation ranking is used. When using this variable, the studies normally use the Carter and Manaster (1990) ranking or the Loughran and Ritter (2004) work (which is also based on the previously mentioned ranking) both relevant for the US market. Following the same reasoning as the Tech dummy, we instead use a more updated and market focused approach. To rank our underwriters, we use the Migliorati and Vismara (2014)[32] reputation of the underwriters of European IPOs that range between 0 and 1. When found, the IPO's underwriter data was retrieved from the Eikon Thomson Reuters, otherwise the underwriters' data was collected directly from the IPO prospectus[33]. When there was more than one underwriter in an issue, the reputation allocated to that issue was relative to underwriter with the highest reputation among the all underwriters in that issue.

[32] Migliorati and Vismara (2014) stated that the Carter and Manaster (1990) underwriter ranking did not cover the underwriters of 67,5% of the European IPOs.

[33] However, we still miss ranking data of 65 IPOs, where 37 correspond to underwriters that are not present in the Migliorati and Vismara (2014) ranking.

4. Descriptive Statistic

4.1. Sample description

Our main study variables are the issues backed by venture capital and the high-technologic companies' issues, which are usually linked since the venture capitalists focus most of their investments in technological, younger and growth companies, so it would be of our interest to analyze it beforehand. That analysis is represented in the Table 1. In high technologic industries, venture capitalist backed issues represent 28% of that industry's IPOs, which is a greater ratio than for non-high technologic where the stands at 19%. However, only 41% of the total VC-backed IPOs belong to a company in a high technologic industry.

Table 1 – Frequencies of venture capital and technologic IPOs

Table 1 describes the frequencies of the venture capital backed and non-venture capital backed IPOs and the frequency of High-Tech and non-Tech IPOs.

	Non-Tech	High-Tech	Total
Non-VC-backed	355	147	502
VC -backed	81	56	137
Total	436	203	639

In the Table 2, we have the yearly distribution of the IPO issues. The first two years of our analysis, 2004 and 2005, are the years with the most IPOs in a single year representing 36% of our sample. During the crisis, considered to be between 2008 and 2011, which is also analyzed further in our research, the number of IPOs clearly dropped and in 2009 there was no IPO registered in our database[34]. Afterwards, the number of IPO raised again but didn't last long since it was cut in almost half from 2014 to 2015. The venture capital backed issues in the pre-crisis period range between 8% and 21% of the total issues per year. During the four years of the crisis, the venture capitalists only took one company to the public market, showing that during that period they avoided engaging in an IPO due to the market circumstances. In the post-crisis period, the scene was different. Apart

[34] In our initial database we had 2 companies issued in 2009 but those observations were dropped due to lack of important data.

from 2012, where the ratio of VC-backed issues is 18%, the number of venture capitalist backed IPOs range between 35% and 57% of the total issues in the year. Following the same reasoning, the technologic industries avoided going public in the crisis period and the issues ratio increased from the pre-crisis period to the post-crisis, even though slightly less drastically.

Table 2 – Yearly distribution of IPOs

Table 2 describes the frequencies of the venture capital backed and non-venture capital backed IPOs and the frequency of High-Tech and non-Tech IPOs distributed by years.

Year	Non-VC-backed	VC -backed	Non-Tech	High-Tech	Total
2004	87	8	62	33	95
2005	116	18	96	38	134
2006	81	12	65	28	93
2007	50	14	45	19	64
2008	15)	0	13	2	15
2010	30	1	23	8	31
2011	23	0	18	5	23
2012	18	4	17	5	22
2013	20	11	16	15	31
2014	30	34	39	25	64
2015	15	20	23	12	35
2016	17	15	19	13	32
Total	502	137	436	203	639

In the Table 3, the IPOs are described by US SIC codes. The Services sector holds almost half of the total issues 42,6%. The industries of Manufacturing and Mining have an issue share of about 20% each. The Retail trade and Transportation, Communications, Electric, Gas and Sanitary service account for 43 IPOs each, while the remaining four industries represent only 5% of the total sample. Most of the companies that venture capitalists take public are in the Services sector, which represent 52% of their total IPO issues, followed by Manufacturing (23%) and Retail trade (15%). The issues made by high-technologic companies are predominantly in the Services sector, where 77% of the total technologic issues belong to that sector. The other two sectors where a technologic company

was issued is Manufacturing (18%) and Transportation, Communications, Electric, Gas and Sanitary service (5%).

Table 3 – Industry distribution of IPOs

Table 3 describes the frequencies of the venture capital backed and non-venture capital backed IPOs and the frequency of High-Tech and non-Tech IPOs distributed by industry.

SIC	Non-VC-backed	VC -backed	Non-Tech	High-Tech	Total
Agriculture, Forest..	6	0	6	0	6
Construction	9	0	9	0	9
Manufacturing	97	32	93	36	129
Mining	117	5	122	0	122
Public Administration	1	0	1	0	1
Retail Trade	22	21	43	0	43
Services	201	71	116	156	272
Transportation, Com..	36	7	32	11	43
Wholesale Trade	13	1	14	0	14
Total	502	137	436	203	639

4.2. Descriptive statistics

In the Table 4 it is presented the descriptive statistic of our database meant for underpricing testing. The underpricing, our dependent variable, has a mean of 9,80% and a median of 6.67%, meaning that our underpricing sample has a right-skewed distribution. The maximum underpricing registered is 186% of Central African Gold Plc and the minimum is an overpricing of 19% of Zareba Plc. Following the same type distribution of the underpricing, the average IPO offer price is 110£ per share, while the median price is 90£ per share. The minimum offer price was set by us as our floor price at 1£ and the highest issue price, 1300£ per share, is registered on the Betfair Group Plc issue. The average size of the IPO issue is £ 75.23 million with a median of £ 10.75 million. The largest issue was made by ITV Plc valued at £ 5781 million and the smallest issue size, which was the floor of our analysis, is £ 1 million, condition met by 5 companies. The market capitalization's

mean of our database's IPO issues is £ 614.22 million and the greatest market capitalization belongs to Polymetal International with a capitalization of £ 209 355 million. Between the 639 IPOs, the average age of the company is almost 2.88 years but the median stays at 1 year old, while the oldest company issuing the IPO is AA Plc which had 109 years at the time. Regarding the underwriter reputation raking, which ranged between 0 and 1, following Migliorati and Vismara (2014), the median value is 0.13 and the mean is 0.28. The highest reputation is 1 achieved by companies issued by UBS Investment Bank and Collins Stewart in the London Stock exchange main market and AIM, respectively. The capital retained by the shareholders at the IPO ranges between 0% and 98.24%, but the mean and median stand above the 50% threshold meaning that most of the shareholders are not willing to float the majority of their shares, thus losing their majority power. Important to note that all variables have the same amount of observations, 639, except for the underwriter reputation and capital retained which have respectively 574 and 534, considerably less observations.

Table 4 – Descriptive statistic

The Table 4 presents the descriptive statistics of our variables. The Underpricing and the Capital retained are presented in %, the Offer Price in £, the Issue size and Market capitalization in thousand £, the Age in years and the Underwriter reputation ranges from 0 and 1.

Variable	N	mean	median	Min	Max
Underpricing (%)	639	9.8	6.67	-19.01	185.71
Offer price (£)	639	110.07	90	1	1 300
Issue size (£)	639	75 230.19	10 750	1 000	5 781 000
Market capitalization (£)	639	614 218.1	37 925	110	209 000 000
Age (years)	639	2.881064	1	0	109
Underwriter reputation	574	0.211586	0.129	0	1
Capital retained (%)	534	61.59	66.26	0	98.24

In respect to our dummy variables, their frequencies are presented in Table 5. Among our 639 IPO sample, 116 of the issues were made on the London Stock Exchange main market, representing about 18% of the total issues, while the remaining 523 were issued on the AIM market. There were only 69 (10.8%) issues made during the crisis period (2008 - 2011). Regarding our financing and industry variables, 21.4% of the issues were backed by venture capital, which accounts for 137 IPOs, and 31.8% of the issues were made by companies in a high technologic industry.

Table 5 – Descriptive statistic – Dummy Variables

The Table 5 describes the distribution of the frequencies of our dummy variables.

Variable	0	1	Total
Market	523	116	639
Crisis	570	69	639
Venture Capital	502	137	639
Tech	436	203	639

Being the dummies related to venture capital and technologic industries our main research focus it is also important to dig deeper in our analysis. In the Table 6 Panel A, we have the descriptive statistic of the issues backed by venture capital against issues without venture capital backing. The median difference significance is tested using the Wilcoxon ranksum test at the 5% level. As hypothesized before by us, the venture capital backed issues present less underpricing, both in mean and median statistics, being about a 2% and 2.5% difference, respectively and the median difference is statistically significant. The size of the issues is almost tripled when we are in the presence of venture capitalist backed company, £ 151 million average of VC-backed IPOs against £ 54 million of non-VC-backed IPOs. The offer price is also relatively higher for the VC-backed issues. However, contrary to the expected, on average, venture capitalists take public older companies[35] even though the median age is 1 year for both cases. For our underwriter reputation ranking, venture capital seems to attract higher reputed underwriters as predicted by the literature. The average reputation is 0.319 for the venture capitalists' companies while for the remaining issues is 0.195[36]. The companies backed by venture capital seem to sell more of their capital at the IPO. On average, VC-backed companies retain only 54% of the shares at the IPO against 63% of non-VC-backed companies. That might happen because, as we saw before, venture capitalists obtain higher offer prices for their portfolio companies incentivizing the shareholders to sell larger shares of capital.

[35] Since our venture capital sample is smaller than the remaining sample, the Age mean difference could be representative of an outlier in the venture capital side.

[36] Important to note that the majority of the underwriter reputation missing observations comes from non-VC-backed companies, where only 7% of the missing values represent venture capital-backed companies.

Table 6 – Descriptive statistic – Venture capital and technologic industry distribution

The Table 6 presents the descriptive statistics of our variables. The Underpricing and the Capital retained are presented in %, the Offer Price in £, the Issue size and Market capitalization in thousand £, the Age in years and the Underwriter reputation ranges from 0 and 1. Market, Crisis, Tech and Venture Capital are our dummy variables. The Panel A presents the sample distribution of venture capital backed and non-venture capital backed issues. The Panel B shows the statistics of the technologic industry against the remaining industries. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Panel A: Venture Capital

	Non-VC-backed			VC-backed			Wicoxon test
Variable	N	Mean	median	N	Mean	Median	Z-Score
Underpricing (%)	502	10.18	7.28	137	8.38	4.81	-2.49**
Offer price (£)	502	96.78	71.5	137	158.7818	150	7 984***
Issue size (£)	502	54 530.52	7 750	137	151 078.6	50 000	9.36***
Market cap. (£)	502	669 987.3	29 738.5	137	409 866.6	95 699	7.83***
Age (years)	502	2.66	1	137	3.69	1	0.19
Underwriter rep.	442	0.18	0.09	132	0.31	0.18	4.23***
Capital ret. (%)	407	63.76	68.8	127	54.66	57.98	-5.54***
Market	502	0.11	0	137	0.43	0	8.53***
Crisis	502	0.14	0	137	0.007	0	-4.28***
Tech	502	0.29	0	137	0.41	0	2.58***

Panel B: High Technologic industries

	Non-Tech			High-Tech			Wicoxon test
Variable	N	Mean	Median	N	Mean	median	Z-Score
Underpricing (%)	436	9.77	6.22	203	9.86	7.58	1.24
Offer price (£)	436	114.31	85.5	203	100.97	98	0.63
Issue size (£)	436	91305.6	11000	203	40 703.7	10 000	-1.24
Market cap (£)	436	825998.2	38121.5	203	159 360.3	36 992	-0.27
Age (years)	436	2.73	1	203	3.21	1	1.24
Underwriter rep.	387	0.21	0.11	187	0.22	0.14	1.05
Capital ret. (%)	358	59.28	64.4	176	66.29	69.51	3.37***
Market	436	0.19	0	203	.15	0	-1.29
Crisis	436	0.12	0	203	0.07	0	1.89*
Venture capital	436	0.19	0	203	0.28	0	2.58***

The venture capitalists' backed issues focus on the main LSE market and avoid the crisis period way more than the overall issues. 43% of the VC-backed IPOs were issued in the LSE main market and only 10 (7%) IPOs were issued by them during the crisis, while out of the remaining issues only 11% were issued in the main market and around 14% issued during the 2008-2011 period. Our significance tests, conducted using the Wilcoxon ranksum test, showed significance in the median difference of every variable, excluding the variable Age which was the only variables that contradicted the theory.

Switching our focus to the industry's issues, we can see on Table 6 Panel B that there is no significant difference on the underpricing mean, even though the 50^{th} percentile the underpricing is 1.5% greater in high technologic industries. In those industries, the size and the market capitalization of the issues are considerably smaller, and the companies go public at later ages. Regarding the reputation of the underwriters, there is no relevant difference between the industries classification. The companies in high technologic industries retain more capital at the IPO than other industries. The shareholders recognize the hidden potential of their technologic products and are more reluctant to sell their capital at the IPO than other industries which are more transparent with their potential. The average capital retained by these industries is 66% while the other industries retain only 59%. During the crisis, out of the 203 high technologic IPOs, only 15 (7.4%) were issued during that time against 12% of other industries IPOs. High-tech companies issue around 15% of the IPOs to the LSE main market, while the non-high-tech industries issue almost 20% to the main LSE market.

The Wilcoxon test only showed significance in the median difference of tech and non-tech industries in the capital retained, in the venture capital backing and in the crisis dummy.

5. Estimation results

In an attempt to show results that are in accordance to the literature, we estimate several regression models to measure the impact of individual variables in our dependent variable, underpricing and the results are presented in the Table 7. Along the models, we group our main study variables, being venture capital (VC) and high-tech (Tech), with several control variables as well as controlling for yearly and industry fixed effects. We aggregated the control variables by firm-specific variables, operation-specific variables and timing and market related variables and we introduced each group of variables separately to account for the individual impact of each group. In the final models, we aggregate all variables together to take out our main conclusions.

Our first model, only includes the two main variables being tested in our research which are the dummies venture capital (VC) and high-tech (Tech). The results of our first model showed no significance on either variable. In our second model, by controlling for yearly and industry fixed effects, the results remain the same, even though the VC coefficient turned out positive by doing so. For our third model, two firm-specific measures are added. The variables added, Age and Market Cap, are both statistically significant while VC and Tech remain insignificant. With the introduction of yearly and industry fixed effects, the variable Age lost its relevance, in the model 4. For our fifth and sixth model, we included two volatility measures, being aftermarket returns' volatility and monthly market returns' volatility and two dummy variables relative to the market and time period, which are Market and Crisis. Independently of the yearly and industry fixed effects, the variables Aftermarket and Market are the only statistically significant variables on these models.

For our last inclusion of individual variables, we add three operation-specific variables being Size, that represents the gross proceeds of the offer, Capret, which is the capital retained by the shareholders in the issue, and UWrep, that represents the reputation of the issues' underwriter. It is also important to note that, in the previous models, were included 639 observations in each of them, but the capital retained and the underwriter reputation only cover 534 and 574 of that observations, respectively.

In the 639 total observations, we had 137 companies backed by venture capital and 203 high technologic issues. By reducing our sample from 639 to 574 observations with underwriter reputation data, 5 venture capital backed firms and 17 high-tech issues are dropped. By shrinking our sample from 639 to 534 observations with capital retained data, 17 VC-backed companies and 30 high-tech issues are also dropped. By eliminating those

Table 7 – OLS estimated results – Underpricing

The Underpricing is the dependent variable of every model. VC is a dummy variable which equals 1 if the IPO is backed by venture capital and 0 otherwise. Tech is a dummy variable which equals 1 if the IPO firm belong to a high technologic industry and 0 otherwise. Age is the age of the company in calendar years at the time of the IPO. Market cap is the logarithm of the market capitalization of the IPO firm at the time of the IPO. Aftermarket is the volatility of the daily returns of the stock from day 2 trough day 20. Marketvol is the market monthly volatility of the daily returns adjusted to LSE and AIM market. Market is a dummy variable which equals 1 if the IPO is issued in the LSE main market and 0 otherwise. Crisis is a dummy variable if the IPO is issued during the crisis period 2008-2011 and 0 otherwise. Size is the logarithm of the issue size or the gross proceeds of the IPO. Capret is the capital retained by the shareholders in the IPO issue. UWrep is the underwriter reputation. VC*Tech is the VC dummy times the Tech dummy. VC*Age is the VC dummy times Age. VC*Market is the VC dummy times the Market dummy. VC*Crisis is the VC dummy times the Crisis dummy. Tech*Age is the Tech dummy times Age. Tech*Market is the Tech dummy times the Market dummy. Tech*Crisis is the Tech dummy times the Crisis dummy. Standard errors in parenthesis. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VC	-1.83	0.24	-0.11	1.68	0.17	1.60	0.48	1.54	3.45	4.76*
	(1.47)	(1.63)	(1.52)	(1.66)	(1.53)	(1.66)	(1.79)	(2.19)	(3.29)	(2.57)
Tech	0.26	1.91	0.09	1.93	0.03	1.19	1.00	2.64*	0.37	1.60
	(1.29)	(1.57)	(1.28)	(1.56)	(1.12)	(1.55)	(1.24)	(1.35)	(1.65)	(2.03)
Age			-1.20*	-1.06					-1.01	-0.91
			(0.65)	(0.66)					(0.71)	(0.87)
Market cap			-1.36***	-1.32***					2.76***	2.67***
			(0.37)	(0.39)					(1.03)	(0.81)
Aftermarket					1.29**	1.24***			1.51***	1.52***
					(0.60)	(0.28)			(0.52)	(0.36)
Marketvol					-0.74**	-0.74			-0.78**	-0.83*
					(0.36)	(0.48)			(0.36)	(0.47)
Market					-4.51***	-3.80**			2.16	2.78
					(1.28)	(1.70)			(2.35)	(2.87)
Crisis					1.63	5.30			1.71	3.69
					(2.17)	(4.46)			(2.79)	(4.67)
Size							-2.37***	-2.27***	-5.14***	-4.93***
							(0.60)	(0.63)	(1.48)	(1.01)
Capret							-0.12**	-0.11**	-0.18***	-0.17***
							(0.05)	(0.05)	(0.06)	(0.04)
UWrep							-1.61	-1.82	-1.60	-2.16
							(2.15)	(2.33)	(2.05)	(2.88)
VC*Tech									-3.09	-4.12
									(3.50)	(3.20)
VC*Age									-0.12**	-0.13
									(0.05)	(0.12)
VC*Market									-2.70	-3.24
									(3.21)	(3.33)
VC*Crisis									-7.36*	-6.88
									(4.00)	(13.90)
Tech*Age									0.20	0.21
									(0.20)	(0.27)
Tech*Market									5.03*	4.43
									(2.94)	(3.49)
Tech*Crisis									0.56	0.70
									(3.89)	(4.44)
Constant	10.11***	26.71*	25.37***	38.33**	9.81***	24.77	40.26***	50.45***	39.72***	41.08***
	(0.77)	(15.52)	(4.01)	(15.74)	(1.45)	(15.21)	(8.13)	(6.62)	(8.75)	(14.38)
Yearly fixed effects	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Industry fixed effects	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Observations	639	639	639	639	639	639	484	484	484	484
R-squared	0.00	0.04	0.03	0.06	0.06	0.08	0.09	0.12	0.17	0.19

observations with missing data, we achieve a complete dataset with a sample of 484 observations where 116 are backed by venture capital and 158 are issued in a technologic industry and are able to conduct our following estimation models.

In the models 7 and 8, the IPO size and the capital retained are statistically significant to explain the underpricing phenomena. Interestingly enough, with the inclusion of this operation-specific variables and by controlling for yearly and industry fixed effects, the variable Tech also showed significance at the 10% level. Finally, in our last two models, we grouped the variables all together, while also adding some interactive variables regarding the VC and Tech variables with some other control variables. The interactive variables are VC∗Tech, VC∗Age, VC∗Market, VC∗Crisis, Tech∗Age, Tech∗Market and Tech∗Crisis. The variables VC∗Age, VC∗Crisis and Tech∗Market are significant in the model 9 but lose their relevance by controlling for yearly and industry fixed effects. In our final and most complete estimation, model 10, the variables VC, Market Cap, Aftermarket, Marketvol, Size and Capret are statistically significant and relevant to explain the underpricing, presenting a R^2 of 19%.

So, to sum up our results, , the venture capitalist presence in the company at the time of the IPO (+), the market capitalization at the time of the IPO (+)[37], the aftermarket returns' volatility (+)[38], the market monthly returns' volatility (−), the issue size (−)[39]and the capital retained (−)[40] by the shareholders at the IPO are significant variables to explain the underpricing and have the expected coefficient sign. The models 5 and 7, 8 and 9 suffer from heteroscedasticity at the 5% level and are corrected using White's heteroscedasticity-

[37] The estimated market capitalization coefficient is positive as defended by Bundoo (2007), Sohail and Raheman (2009) and Bansal and Khanna (2012). However, we are also aware that since we have two size measures in our model, the Size and Market Cap variables, the powerful measure takes the full explicative power, while the other measure just weights down the weaker measure power.

[38] The positive estimated aftermarket returns' volatility coefficient is as expected, since if the stock is more volatile after the IPO first day, it is expected that that very same first day was also more volatile represented by bigger underpricing (Megginson and Weiss, 1991).

[39] The negative relation between the issue size and the underpricing is as expected, as pointed out by several literature studies, where greater issues are less uncertain, since they normally represent more stablished firms (Beatty and Ritter, 1986).

[40] Following signaling theories, the capital retained variable has the expected negative estimated coefficient sign.

consistent standard errors which are presented instead of the heteroscedastic models. For the remaining models, we reject heteroscedasticity at the 5% level.

Across our 10 models, the variables VC and Tech only showed significance in one model each. However, while VC showed significance in our most complete result which allows for strong conclusions, Tech showed significance in an intermediate and less complete model. Therefore, since the recent literature also lacks evidence of high-technological industry influence over underpricing, the results are as expected. The researches where technological industries were found to be more underpriced, such as Loughran and Ritter (2004), were made shortly after or included the dotcom bubble period. After so many years passed, nowadays the technologic has a much bigger influence in our daily lives, including the financial markets. The results found suggest that the tech industry is now more mature and that the investors easily assess the technological values of such stocks.

In the side of venture capital, the expectations were always ambiguous even though we expected a negative coefficient. Barry et al. (1990) and Megginson and Weiss (1991) as the first researchers in this topic found evidence of VC-backed companies suffering from less underpricing, as did Brav and Gompers (1997) a few years later, just to name some. However, there is other authors that defend otherwise. Bradley and Jordan (2002), Arikawa and Imad'Eddine (2010) and Cao et al. (2013) found no difference between VC and non-VC underpricing. Francis et al. (2001), Loughran and Ritter (2002) and (Lee and Wahal, 2004) showed that VC-backed issues suffer greater underpricing that companies without such support. Indeed, our results also provide evidence of greater underpricing on IPO issues backed by venture capitalists.

There is a pair of possible reasons behind such phenomenon, which we will try to explain. First, following the statistics provided by Megginson and Weiss (1991), they report that venture capitalists keep most of their invested capital in the companies after the IPO, meaning that, if underpricing is a cost supported by the issuer's shareholders, the venture capitalists also bear the cost of underpricing themselves. However, they only accept to support that cost due to reputational concerns.

The venture capitalists operate through funds financed by limited partnerships which usually last from ten years and during that finite period of time, the venture capitalist must invest, liquidate their investments and deliver the money back to their original fund investors. Since most of the profit created by VC firms comes from IPO process, they must have a strong reputation of being able to take companies to the public market to get further

investment for their funds (Gompers, 1996). Based on those reputation concerns, the venture firms are keen to accept the cost of higher underpricing because taking the firm public will ease their access to further fundraising since it signals quality and Gompers (1996) also showed that younger venture capital firms will take higher risks by taking public younger and less prepared companies accepting even higher underpricing, just to increase their reputational levels, which is consistent with the idea that venture capitalists privilege the reputation granted by taking a firm public over the cost of underpricing. That argument was tested by Lee and Wahal (2004), which showed evidence that younger VC firms take public younger companies and that there is a benefit to bear the cost of underpricing due to additional capital fundraising quickly after the IPO.

Other plausible reason for the higher underpricing of venture capital backed firms, would be that the market understands the presence of venture capitalists as specialists in young and growth companies and that would provide greater value in the post-IPO period. This argument is based on two simple assumptions. The first is that the venture capitalist are specialists in the sectors in where they invest which is an easily accepted assumption in the literature. The second assumption is that the venture capitalists retain their shares at the IPO to influence the companies in the post-IPO period, which is also accepted, since Meg e Weiss showed that, in their sample, venture capitalists hold, on average, 36,6% before the IPO and 26,3% immediately after going public. This expectation of a future performance improvement would create greater demand for the stock at the IPO, which generate greater underpricing. To assess the impact of the venture firms in the post-IPO period, we engage in a deep analysis regarding the post-IPO operating performance of venture capital backed and non-backed issues.

6. Operating performance

Before we tune in into our operating performance sample and methodology it is of prominent importance to understand what has been done in the literature in the past regarding this issue.

6.1. Literature review

In every relevant study addressing the operating performance in the pre and post-IPO periods, observed a decline in their operating performance measures, namely the operating return on assets and the operating cash-flow deflated by assets, from the pre-IPO to the post-IPO levels (see Jain and Kini (1994, 1995), Mikkelson et al. (1997) and Teoh et al. (1998) for the US, Pagano et al. (1998), Coakley et al. (2004) and Khurshed et al. (2005) for European markets and Cai and Wei (1997) and Kutsuna et al. (2002) for Asian markets). There are two main theories describing the operating underperformance. The first assents in the information asymmetry problem caused by increasing agency costs due to reduced ownership after the IPO and managers' enrollment in projects which are non-value maximizing. The second is based on the market timing theory, based on the idea that the owners want to go public in times when their cash-flow achieve a relative high peak[41], which is consistent with the idea that issuers mask their accruals before the IPO causing an overstatement of operating levels before the IPO and an understatement in the post-IPO period, idea that was proved by Teoh et al. (1998).

However, venture capitalists helps relieving some of those agency costs due to their certification power and because of that their firms are able to produce better operating results (Jain and Kini, 1995). Coakley et al. (2004) found that a significant underperformance after the IPO is only significant in the high-technologic industry but were not able to find differences between the performance of both venture capital backed and non-venture capital backed companies. They did, however, find a negative relation between the underpricing and the venture reputation[42] with the operating performance.

[41] Benninga et al. (2005) found evidence to prove this point.

[42] Lerner (1994) posit that better reputed venture capitalists bring companies to the public at more optimal times than less experienced venture capitalists. The IPO timing matches, most of the times, with the accruals peak.

6.2. Sample

To address the post-IPO operating performance, we follow the Megginson and Weiss (1991) matching firm method to construct our sample. From our initial sample, we matched each venture capital backed firm with a non-venture backed firm within the same industry, measured by the 3-digit SIC code[43], and as close as possible regarding the issue size, to obtain a total sample of 194 firms, 97 venture capital backed firms and 97 non-venture capital backed firms[44]. To measure the operating performance, we use the operating return on assets and operating cash-flows divided by assets which has been a widely used approach in similar studies (see Kaplan (1989), Smith (1990), Jain and Kini (1994, 1995) and Jenkinson and Sousa (2012)). The operating return on assets, our first measure of operating performance, offers a measure of efficiency regarding assets' usage and is computed by deflating the operating income, which equals the net sales minus the cost of goods sold and selling, general and administrative expenses, by the total assets. The second measure is obtained by dividing the operating cash-flows by assets and gives us a preview of the value of the firm since it is a relevant component of the NPV, being a suitable operating performance indicator. It is important to note that all accounting values are measured before taxation to guarantee that the changes are caused by operating results and not by tax or financial decisions. To measure the improvements, or not, of the operating performance, the median[45] change is computed for each operating performance variable, from the fiscal year prior to the IPO to the fiscal years 1, 2 and 3 after the IPO[46]. To test if the changes in operating performance are significant, the Wilcoxon signed rank is performed as well as an OLS regression.

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[43] In some industries, measured by the 3-digit SIC Code, every IPO was backed by venture capital. In such cases, we used the 2-digit SIC Code to match the firms. The same reasoning was used in the case of a huge difference regarding the issue size.

[44] We had the intention to test the operating performance until 3 years after the IPO. Since our sample period ranged from 2004 until 2016, we do not have enough operating data to study the most recent IPOs. We dropped the 2016 IPOs and for the 2015 IPOs, we measured only the operating performance until 2 years after the IPO.

[45] Knowing that the operating performance measures could be skewed and since the mean is more sensitive to outliers, the median is used to ensure more normality.

[46] The median change is computed in the following way: $Operating\ measure_{t-i} - Operating\ measure_{t}$, $t =$ IPO fiscal year, $i = 1,2,3$

6.3. Descriptive statistic

In the Table 8 Panel A, we have the statistics of the new sample constructed, and the outcome follows the theory and our previous sample results. The underpricing and the capital retained of venture capital backed firms are lower than for non-venture capital backed firms, but only the latter show statistical significance. The offer price, the issue size and the market capitalization are larger for VC-backed firms and the differences are statistically significant. The remaining variables, age and underwriter reputation, present no relevant differences.

To assess the operating performance, we collected accounting and operating variables from the Thomson Reuters Worldscope database and the descriptive statistics of those variables are presented in the Table 8 Panel B. Since the venture backed firms' issues are larger than the non-venture backed issues, we expect that firms themselves are also larger for venture-backed firms, which is proven by the significant differences between the assets and the sales of venture backed and non-venture backed firms before and after the IPO. As expected every firm grows in assets and sales consistently after going public, but the difference between both types of firms increases from the year before the IPO until the year after the IPO and decreases afterwards, however, the difference is still statistically significant in every year, apart from the sales difference in the third year after the IPO. Focusing our attentions in the operating side of the firms, the venture capitalists backed firms present significant higher operating income in the year prior to the IPO, in the year after the IPO and higher operating income and cash-flow from operating activities 3 years after the issue, while in the remaining years the difference is not statistically significant.

Table 8 - Descriptive statistic – New sample

The Table 8 presents the descriptive statistic of our new sample. In the Panel A is presented the underpricing-related variables distribution of venture capital backed and non-venture capital backed IPOs. The Underpricing and the Capital retained are presented in %, the Offer Price in £, the Issue size and Market capitalization in thousand £, the Age in years and the Underwriter reputation ranges from 0 and 1. In the Panel B is presented the operating performance related variables distribution of venture capital backed and non-venture capital backed IPOs. Values are in thousand £.

Panel A

		Non-VC-backed		VC-backed		Wicoxon test
	N	Mean	Median	mean	Median	Z-Score
Underpricing (%)	97	8.66	5.86	7.60	4.55	-1.30
Offer Price (£)	97	143.19	126	164.74	148	1.97**
Market Capitalization (£)	97	298 152	73 075	395 385.2	95 699	1.92*
Issue Size (£)	97	73 831	20 000	147 036.5	53 942	3.53***
Age (years)	96	2.63	1	2.85	1	0.27
Capital Retained (%)	64	63.08	67.42	54.6	59.64	-2.91***
Underwriter reputation	86	0.25	0.14	0.33	0.2	1.55

Panel B

		Non-VC-backed		VC-backed		Wicoxon test
	N	Mean	median	mean	Median	Z-Score
Assets $_{t_{-1}}$	97	77 471.4	11 167	207 484.9	51 515	3.64***
Assets $_{t}$	97	125 990	24 399	239 980.3	65 735	2.75**
Assets $_{t_{+1}}$	95	174 943	34 107	276 499	85 254	2.34**
Assets $_{t_{+2}}$	90	230 807	48 645.5	501 405	87 974	2.04**
Assets $_{t_{+3}}$	65	292 045	57 282	885 855.2	90 965	1.82*
Sales $_{t_{-1}}$	97	107 985	13 848	186 087.9	45 404	2.84***
Sales $_{t}$	97	129 223	18 419	214 803.7	59 310	2.71**
Sales $_{t_{+1}}$	95	159 713	28 030	252 569.3	82 875	2.63**
Sales $_{t_{+2}}$	90	215 104	35 770.5	388 774.8	88 871	2.06**
Sales $_{t_{+3}}$	65	268 803	40 390	478 119.7	90 965	1.24
Operating income $_{t_{-1}}$	97	6 288.45	669	20 094.2	2 496	1.86*
Operating income $_{t}$	96	8 669.14	1 704	25 026.18	4 716.5	1.63
Operating income $_{t_{+1}}$	93	10 165.8	2 396	28 763.84	4 490	1.65*
Operating income $_{t_{+2}}$	86	11 318.7	2 812.5	49 002.15	5 785.5	1.37
Operating income $_{t_{+3}}$	63	13 089.9	729	61 340.92	7 809	2.54**
Operating cash-flow $_{t_{-1}}$	97	6 114.99	1 074	17 092.44	896	-0.60
Operating cash-flow $_{t}$	96	8 916.27	1 523.5	23 535.83	2 744	1.56
Operating cash-flow $_{t_{+1}}$	93	13 918.5	1 590	26 892.84	2 039	1.11
Operating cash-flow $_{t_{+2}}$	86	17 386.6	2 699.5	51 510.94	4 195.5	1.34
Operating cash-flow $_{t_{+3}}$	63	23 437.5	2 893	70 033.6	9 624	2.36**

Switching to the core side of our topic, the operating return on assets and the operating cash-flow divided by total assets, presented in Table 9, show no significant differences on each year operating measures of both venture backed and non-venture backed firms. However, the question remains: Is the operating performance improvement larger for venture capital backed companies after going public? Basing our answer in the median difference of the operating return on assets, there is enough consistent evidence of a difference between the improvements of our operating measure from before the IPO to the post-IPO period, where the venture capitalists significantly influence positively the operating performance of their portfolio's companies.

Table 9 – Median difference tests

The Table 9 presents the statistic relative to our operating performance measures. Values in thousand £. +, *, ** and *** represent 15%, 10%, 5% and 1% significance levels, respectively.

Panel A (Absolute values)						
		Non-VC-backed		VC-backed		Wicoxon test
	N	Mean	median	Mean	median	Z-Score
Operating return on assets $_{t_{-1}}$	97	-0.290	0.063	0.006	0.054	-0.31
Operating cash-flow deflated by assets $_{t_{-1}}$	97	-0.224	0.074	0.069	0.033	-1.47
Panel B (% Change)						
Operating return on assets $_{t_{-1}\ to\ t_{+1}}$	93	0.093	-0.286	0.010	-0.042	1.87*
Operating return on assets $_{t_{-1}\ to\ t_{+2}}$	86	-0.075	-0.377	0.194	-0.254	1.64+
Operating return on assets $_{t_{-1}\ to\ t_{+3}}$	62	-0.565	-0.672	0.387	-0.469	1.9*
Operating cash-flow deflated by assets $_{t_{-1}\ to\ t_{+1}}$	93	-0.209	-0.404	-6.723	-0.342	0.54
Operating cash-flow deflated by assets $_{t_{-1}\ to\ t_{+2}}$	86	0.099	-0.432	-6.426	-0.420	0.03
Operating cash-flow deflated by assets $_{t_{-1}\ to\ t_{+3}}$	62	-0.193	-0.539	-8.844	-0.479	0.13

The operating cash-flow deflated by assets showed no significant differences in the improvements between the year prior to the IPO and the years after the issue. However, it is not sufficient to take any meaningfully conclusions yet. To profoundly address this issue, we estimate an OLS regression using the operating variables and their respective return on the assets as dependent variables.

6.4. Estimations results

In our analysis, we employ several OLS regressions using each operating variable as dependent variable. Apart from the core of our study, the venture capital dummy, we also included other relevant control variables employed in other studies (see Coakley et al. (2007)), such as underwriter rank, capital retained, a high-technologic dummy and the issue size. The operating variable growth, assets growth and sales growth are also included as control variables. The inclusion of the sales is relevant because an increase of our operating performance variables could be motivated by a revenues' increase, therefore, we avoid suffering from an omitted variable bias.

Our results, presented in the Table 10 are very consistent with the Wilcoxon test results, regarding both operating measures. The venture capital backing reported positive significance in the incremental operating return on assets from year t_{-1} to t_{+1}, t_{+2} and t_{+3}, which is, apart from the operating income growth, the only significant variable across the three periods, while the issue size is relevant 3 years after the IPO.

In our second operating measure, as in the Wilcoxon tests, the results are different. The venture capital dummy never showed significance in the incremental change of the operating cash-flow deflated by assets.

If, on the one hand, regarding the operating return on assets, our results are indicative of a greater operating performance (or less worse performance) in the post-IPO period of the venture capital backed firms, supported for a greater incremental performance after the issue, on the other hand, in the operating cash-flow measure, we couldn't find any significance of the venture capitalist presence being a positive and significant indicator of greater operating improvements in the post-IPO period. We argued before that the venture capital presence at the time of the IPO signals a better operating performance which increases after going public and that the underpricing shows the investors' excitement over the future expectations of the firm, but even though we couldn't find evidence of in both operating performance measures, our results should be enough to back our argument as plausible.

Table 10 - OLS estimated results – Operating performance

The Table 10 presents our estimation results. Models 1, 2 and 3 have the percentage change of the operating return on assets from the year before the IPO to year 1, 2 and 3 after the IPO, respectively. Models 4, 5 and 6 have the percentage change of the operating cash-flow deflated by assets from the year before the IPO to year 1, 2 and 3 after the IPO, respectively. VC is a dummy variable which equals 1 if the IPO is backed by venture capital and 0 otherwise. Tech is a dummy variable which equals 1 if the IPO firm belongs to a high technologic industry and 0 otherwise. UWrep is the underwriter reputation. Size is the issue size or the gross proceeds of the offering. Capret is the capital retained by the shareholders at the IPO. SalesG, OpincG, AssetsG and OpCFG are the sales, operating income, assets and operating cash-flow growth from the year prior to the IPO to the respective year of the model. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

	t_{-1} to t_{+1}	t_{-1} to t_{+2}	t_{-1} to t_{+3}	t_{-1} to t_{+1}	t_{-1} to t_{+2}	t_{-1} to t_{+3}
Variables	Operating return on assets	Operating return on assets	Operating return on assets	Operating cash-flow deflated by assets	Operating cash-flow deflated by assets	Operating cash-flow deflated by assets
VC	0.45***	0.53**	0.66*	-0.29	-0.10	-0.17
	(0.16)	(0.24)	(0.40)	(0.34)	(0.47)	(0.48)
Tech	-0.28*	-0.42	-0.34	0.40	0.94*	1.30
	(0.17)	(0.26)	(0.54)	(0.41)	(0.53)	(0.94)
UWRep	-0.22	-0.53	-1.34	0.77	1.03	4.07
	(0.35)	(0.47)	(1.01)	(0.85)	(1.42)	(2.87)
Size	-0.06	-0.06	-0.34*	-0.19	-0.04	0.47
	(0.07)	(0.09)	(0.17)	(0.13)	(0.19)	(0.47)
Capret	-0.00	-0.01	0.01	0.01	0.01	-0.03
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.02)
SalesG	0.00	0.00	-0.01	-0.00	-0.00	0.00
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
OpincG	0.15***	0.15***	0.18***	-	-	-
	(0.01)	(0.02)	(0.02)	-	-	-
AssetsG	-0.01	-0.01	-0.00	-0.07**	-0.11***	-0.27**
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.12)
OpCFG	-	-	-	0.11*	0.23***	0.28**
	-	-	-	(0.06)	(0.06)	(0.13)
Constant	-0.71	-0.44	-4.14*	-3.06*	-1.74	5.11
	(0.84)	(0.99)	(2.18)	(1.62)	(2.27)	(5.27)
Observations	106	104	78	106	104	78
R-squared	0.59	0.55	0.75	0.29	0.60	0.55

7. Conclusions

We conducted a deep investigation in one of the greatest IPO anomalies, which has been focus to a great variety of researchers, the underpricing. We studied the impact on the IPO underpricing of the innovation, using a dummy variable for the high technologic industries and thus, more innovative firms, and of the venture capital backing, using a dummy variable as well and several other interactions.

The more technologic intensive industries were neither more or less underpriced than any other specific industry, as we couldn't find any significance in the respective dummy or its interactions. The firms which contained venture capital funds among their shareholders at the time of the IPO showed, on average, larger underpricing than the remaining firms. We hypothesized that market perceives the venture capitalist presence at the IPO as a specialized group which provides superior knowledge that later will correspond to a greater operating performance and, therefore, in the very first trading day the market will trade accordingly generating greater first day returns due to overexcitement, creating higher levels of underpricing.

We tested this hypothesis using a matched-firm methodology and found that the venture capitalists provide greater incremental operating performance from the pre-IPO to the post-IPO period. Furthermore, the underpricing is positively related with the changes in operating performance after going public, which corroborates our prior argument about the excitement effect of the future operating expectations. Other possible explanation for the positive relation between venture capitalists and underpricing was developed by Gompers (1996) defending that the venture capitalists prefer the investments liquidity over lower amounts of underpricing due to reputational concerns, because having the reputational ability of taking firms public will generate further increased fundraising. Hypothesis that was tested and proved by Lee and Wahal (2004).

7.1. Limitations and further research

Our study centered on the venture capital and innovation. Both industries are based on a secretive rule. Venture capitalists invest on private companies where, most of the time, little or nothing is known about them and the companies which rely on innovation to succeed are reluctant to disclose much information about their innovative activities due to the risk of

losing competitive advantage. Is hard to have access to that private information which imposed some limits to our research.

We didn't have deeper information about venture capitalist funds so that we could use their age, number of past IPOs, number of venture capitalists in each IPO firm and the percentage of shares hold and sold before and after the IPO as inputs in our regressions as was made in previous researches. We also had limited access to innovation measure such as R&D expenses and the number of patents. With greater access with could have computed our own measure of R&D intensity, as was made in other studies, and use it as an extra innovation input in our underpricing analysis. The same applies for the number of patents, which is seen as the innovation output.

Due to restricted data, as said before, it was not possible to test the Gompers (1996) explanation for our results, therefore we propose that analysis for further researches. It would be also interesting to analyze the explicative power of the high technologic industries using the possible industry maturation as an approach.

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9. Appendixes

Appendix 1

KPMG (2015) grouped the 16 most relevant industries to the technology sector using the UK SIC classification system[47]. They achieved the following sample of UK SIC Codes:

- Software publishing – SIC 582
- Computer programming, consultancy and related activities – SIC 620
- Data processing, hosting and related activities; web portals – SIC 631
- Manufacture of computer, electronic and optical products – SIC 26
- Manufacture of electrical equipment – SIC 27
- Manufacture of air and spacecraft and related machinery – SIC 303
- Manufacture of electrical and electronic equipment for motor vehicles – SIC 2931
- Manufacture of other parts and accessories for motor vehicles – SIC 2932
- Wireless telecommunications activities – SIC 6120
- Satellite telecommunications activities – SIC 6130
- Other telecommunications activities – SIC 6190
- Other financial service activities, except insurance and pension funding – SIC 6499
- Other information service activities – SIC 6399
- Research and experimental development on biotechnology – SIC 7211
- Other research and experimental development on natural sciences and engineering – SIC 7219
- Engineering design activities for industrial process and production – SIC 71121

[47] The UK SIC codes were converted into US SIC Codes to compare with other studies regarding the usage of technologic sectors.