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IPOs of High-tech companies: Activity, Pricing, Allocations and Performance

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Biographical Note

Ana Catarina Tavares Gomes was born in Oliveira de Azeméis in 1996. Her taste for mathematics, numbers and economics led her to pursue a degree in economics at the Faculdade de Economia da Universidade do Porto (Faculty of Economics of the University of Porto). She continued her studies at the Master in Finance in the same Faculty, which culminates with this dissertation.

She is starting her professional career at Millennium bcp, in the area of Corporate Finance. In the past she also had a professional experience during the summer at Banco de Portugal.

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Abstract

We explore the first day returns and the long-run underperformance of high-tech initial public offering (IPO) firms in a sample of 603 IPOs, on U.S. exchanges, from January 1, 2001 to April 18, 2019.

Underpricing is a recurrent phenomenon, occurring for all years under analysis, excluding 2008. The average first day return of the 603 IPOs is 19.2%. Some variables appear significant in explaining the underpricing, being statistically significant in the regressions we conduct: the age of the companies at the time of the IPO, the offer size, the 6-month lagged underpricing, the weight of the total size of the Secondary Public Offerings held within 3 years after the IPO compared to the amount of the initial offer size, as well as a proxy of uncertainty calculated by us. However, we believe that variables related to allocation of shares can also be very important in explaining underpricing.

Regarding the performance of the IPOs, we conclude that underperformance is not as general a phenomenon as underpricing, with high-tech IPOs having an average 3-year holding period total return of 26.2%. However, Fama and French (1993) three-factor model regression evidence the existence of underperformance (-10.3 basis points per month, about -1.24% per year), for the entire sample. Additionally, Event Time Results show that underperformance is a phenomenon that occurs in the technology industry for IPOs that had a negative return on the first day of trading and for smaller IPOs, defined as having gross proceeds under $50 million.

Therefore, our results seem to show a very interesting conclusion: we find evidence of both underpricing and underperformance phenomenon in our sample, however, there seems to be no sign of overreaction. On the contrary, IPOs who perform the worst on day one are also the worst performers over the next three years.

Key-words: Initial public offerings, IPO, Underpricing, Long-run performance, Underperformance, Fama and French

JEL-Codes: G12, G14, G24, G32

Resumo

Estudamos os retornos obtidos no primeiro dia e a *underperformance* no longo prazo das 603 empresas tecnológicas que conduziram a sua Oferta Pública Inicial (OPI), nas bolsas dos E.U.A., de 1 de janeiro de 2001 a 18 de abril de 2019.

O *underpricing* é um fenómeno recorrente, verificado em todos os anos analisados, exceto em 2008. O retorno médio no primeiro dia das 603 empresas é de 19,2%. Algumas variáveis parecem significativas na explicação do *underpricing*, sendo estatisticamente significativas nas regressões que realizamos: a idade das empresas na data da oferta, o tamanho da oferta, o *underpricing* desfasado 6 meses, o peso do tamanho total das ofertas públicas secundárias realizadas até 3 anos após a oferta inicial em comparação com o valor do tamanho da oferta inicial, bem como uma *proxy* de incerteza por nós calculada. No entanto, acreditamos que variáveis relacionadas com a alocação de ações também possam ser muito importantes na explicação do *underpricing*.

Em relação ao desempenho das empresas, concluímos que o *underperformance* não é um fenómeno tão recorrente como o *underpricing*, com o retorno médio das ações durante os 3 anos após o primeiro dia da oferta a atingir os 26.2%. No entanto, a *Fama and French (1993) three-factor model regression* evidencia a existência de *underperformance* (-10,3 pontos base por mês, cerca de -1,24% ao ano), para toda a amostra. Além disso, os *Event Time Results* mostram que o *underperformance* é um fenómeno que ocorre no setor de tecnologia para as OPIs que obtiveram um retorno negativo no primeiro dia de negociação e para as OPIs mais pequenas, definidas como sendo inferiores a $50 milhões.

Assim, os nossos resultados parecem mostrar uma conclusão muito interessante: encontramos evidência dos fenómenos de *underpricing* e *underperformance* na nossa amostra, no entanto, não parece haver sinal de *overreaction*. Pelo contrário, as OPIs que apresentam o pior desempenho no primeiro dia também são as que apresentam o pior desempenho nos três anos seguintes.

Palavras-chave: Oferta Pública Inicial, OPI, *Underpricing*, *Long-run performance*, *Underperformance*, Fama and French

Classificação JEL: G12, G14, G24, G32

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1. Introduction

We intend to study the Initial Public Offerings (IPOs) of high-tech companies after 2000, discussing the reasons of this type of companies for going public; the pricing of the shares, presenting some possible explanations for the underpricing; the allocation of shares; and the long-run performance. There are many studies that address these issues related to IPOs, but as far as we know, there is no study analyzing all these issues for this industry and for this particular period. In fact, most studies focus on the dot-com bubble period and the period preceding it, while we intend to study the period that followed it.

The main research questions that we intend to answer are:

Which are the financial and non-financial underpricing value drivers of high-tech companies in the period 2001-2019?

What is the long-run performance of high-tech IPOs compared to other high-tech companies? And compared to all companies?

The importance of high-tech companies currently is huge. From our research using data available on the NASDAQ website (NASDAQ, 2018), we concluded that technology companies, totaling a market capitalization of $8,656 trillion in the NASDAQ, NYSE and Amex markets, account for 20.2% of the total market capitalization in those markets. In fact, 5 of the 6 largest companies in terms of market capitalization listed on those three markets currently are companies in the technological sector, with two of them holding their IPO after 2000.

The number of companies in this industry that decide to hold an IPO is different from year to year. In fact, in 2007 the number of technology companies that realized an IPO was of 68, whereas in the following year only 4 companies of this industry decided to go public. Therefore, it will be relevant to study the motivations for high-tech companies to go public and why its IPO volume is very different among the years.

Ritter and Welch (2002) state that the topic of underpricing "has enjoyed a resurgence of activity, motivated by the astonishingly high first day returns on IPOs during the Internet bubble" (p. 1822). These high levels of underpricing remains quite current. It should be noted that LinkedIn IPO, for example, had a first day underpricing of 109% (Baldwin & Selyukh, 2011), in 2011, and that Dropbox IPO, in 2018, rewarded the investors with a first day return of 36% (Bullock & Waters, 2018). Therefore, in the study of the pricing it is important to calculate the average first day returns in each year, trying to explain the values obtained. Furthermore, it is important to explore which are the financial and non-financial underpricing value drivers of these companies.

It is also important to consider the allocation process, because among other things, it seems to be important to help to explain the underpricing puzzle. According to Ritter and Welch (2002) "how IPO shares are allocated is one of the most interesting issues in IPO research today" (p. 1796).

Additionally, we intend to study the long-run performance of high-tech companies after the offering, measuring both the absolute and relative performance. Several authors document that companies that do IPOs underperform the others in the long run. Therefore, it is important to realize if it is the case for high-tech companies in the period that we intend to analyze and the possible reasons for that to occur.

We have no doubt about the importance of high-tech companies in the current economic situation, nor about the importance of issues related to Initial Public Offerings, not only for academics, but for all who interact with the financial world. Therefore, we intend that our research provide a complete and accurate analysis of the high-tech IPOs.

After this Introduction, Chapter 2 will present the Literature Review. Chapter 3 describes the methodology followed and data used. In Chapter 4, we survey IPO activity and Chapter 5 covers IPO underpricing. Chapter 6 shows evidence and analysis on the long-run underperformance of IPOs, and Chapter 7 presents the main conclusions and suggestions for future research.

2. Literature Review

2.1. Activity

When the topic of a research is about IPOs, independently of the period and industry that we intend to analyze, we should start by understand the motivations behind the decisions of the companies to go public. Therefore, in this research, when analyzing the existing literature, the first questions that we should try to answer are: "Why high-tech companies decide to go public?" and "What is the optimal timing for high-tech companies IPOs?"

Most of the existing literature focus in IPOs of all industries, however we believe that many conclusions of these studies also apply to high-tech companies. In fact, according to Ritter and Welch (2002) "IPO volume fluctuation in the late 1990s is attributable almost entirely to the tech sector" (p. 1799).

2.1.1. Theories of the going public decision

Zingales (1995), Benninga, Helmantel and Sarig (2005) and Pástor, Taylor and Veronesi (2009) focus on some trade-offs faced by entrepreneurs.

Zingales (1995) focus on the importance of IPOs as a way of optimizing the structure ownership of entrepreneurs and, therefore, maximizing the proceeds that they could raise by selling their business. These entrepreneurs have to decide to go public or to remain private and, in the case of going public, what the stake they will sell. To make these decisions, they stand before a trade-off between the majority control and dispersed ownership and should balance these two factors in the best way to maximize their wealth.

Benninga et al. (2005) studied the timing of the IPOs exploring the entrepreneurs' trade-off that exists between the gains of diversification and the benefits of being private. Their results are in accordance with the existence of "hot issue markets", namely within a given industry. They demonstrate that when cash flows are sufficiently high and when stock prices are also high, the firm decides to go public, given the cross-sectional correlation of cash flows, mainly within industries. Pástor et al. (2009) explore the same trade-off as Benninga et al. (2005) and conclude that launch an IPO is optimal when the expected future profitability of the companies is high enough.

The studies of Chemmanur and Fulghieri (1999) and Altı (2005) are based on the existence of private information.

Chemmanur and Fulghieri (1999) assume that the initial owners of the companies have private information about the value of their companies, but outsiders can evaluate the company at a cost and therefore, can reduce the informational disadvantage that exists. The equilibrium timing of the decision to go public, according to the authors, is determined by the trade-off the company faces between avoiding the risk-premium that the venture capitalists demand and minimizing the duplication of information production by outsiders. The authors conclude that, in equilibrium, a company launch an IPO if there is enough information about it in the public domain and the authors also reach that companies in industries which have higher technological uncertainty choose to launch an IPO at an earlier stage of their lives, when compared to the others.

In accordance with Altı (2005), the private information on common valuation factors of investors participating in a pioneer IPO are reflected in the outcomes of that public offering, which, in turn, result in a relatively easier pricing of subsequent IPOs and, therefore, attracts more firms to going public. Higher offer price realizations for the companies that going public first leads to a stronger spillover effect, and consequently, to a larger number of companies going public (Altı, 2005), which is consistent with the existence of hot markets.

Some authors rely on the possibility of grab market share from rivals as an important motivation to go public (Schultz & Zaman, 2001; Chemmanur & He, 2011) and on the product market characteristics (Chemmanur & He, 2011; Chemmanur, He, & Nandy, 2010).

Schultz and Zaman (2001) find evidence that companies became public to gain share in the market, evidence that is supported by the high number of mergers and acquisitions and strategic alliances involving these companies. Chemmanur and He (2011) also consider an important motivation to become public the possibility of grabing market share from rivals who continue private and discovered that companies may become public even in situations when they do not need money, driven by the likelihood of their product market rivals launching an IPO. Likewise, Chemmanur et al. (2010) discovered that the product market characteristics of a company affect significantly its probability of become public, with companies that have a larger size, higher growth of the sales, share in the market, capital intensity and productivity, having more probability of become public. Additionally, according to Chemmanur et al. (2010) companies in industries with riskier cash flows, higher liquidity, less competition and fewer information asymmetries have more probability of doing an IPO.

Some investigations focus more on high-tech companies. For example, the study of Subrahmanyam and Titman (1999) investigated, among other issues, why public funding may be the most appropriate financing solution for high tech companies while it may not be for other industries. Their model suggests that when companies introduce new products, they prefer to become public and also suggests that the benefits of enter into the public market are greater when the markets are larger and have more liquidity.

Maksimovic and Pichler (2001) demonstrate that in an industry characterized by fast technological change, the competitive and the technological risks have implications on the timing of offerings. The authors conclude that in industries that seems by the public to be viable, in which there are low chances of being displaced by competitors that are more technology advanced, and in which there are low costs of development, will occur earlier public financings.

Pástor and Veronesi (2005) as well as Benninga et al. (2005) provide explanation for IPO waves, defending that they are a response to the variation of market conditions during time. Pástor and Veronesi (2005) argue that the waves are a consequence of rises in the expected aggregate profitability, drops in the expected market return and higher *ex-ante* uncertainty about the average future profitability. According to the same authors, technological revolutions are expected to be associated with high *ex-ante* uncertainty, so one can expect that IPO waves follow the technological revolutions.

Some authors conclude that the market-to-book ratio play an important role in the decision to go public (Lerner, 1994; Pagano, Panetta, & Zingales, 1998). Lerner (1994) concludes, using a sample of venture-backed biotechnology companies, that venture capitalists decide to take companies public at market peaks. From a large sample of Italian companies, Pagano et al. (1998) conclude that an IPO is more probable to occur when the market-to-book ratio of the industry and companies are larger, and that the companies that become public appear to have reduced their costs of borrowing. One of the most interesting findings of these authors is that companies go public after high investment and growth and not before, as expected.

According to Lowry and Schwert (2002), since in the moment of setting offer prices the underwriters do not fully incorporate all the available information, there are relevant biases in the offer prices. These biases lead to a high autocorrelation in the IPO volume and to more companies becoming public after periods of high underpricing. In fact, the information learned during the registration period drive these tendencies, with more positive information causing higher initial returns and, consequently, more companies going public. Yung, Çolak, and Wang (2008) also state that there is a correlation between the volume and underpricing of IPOs. In their model positive shocks like an increase in the productivity of capital, generates higher demand for capital and consequently lead to more companies going public.

Lowry (2003) finding that the demand for capital and investor sentiment are the most important contributes to the fluctuations of IPO volume. In fact, the authors document that there is a positive relation between these two factors and the number of companies that choose to go public, and a negative relation between the IPO volume and the adverse selection costs.

Brau and Fawcett (2006) attempt to compare the perspectives of CFOs with the prevailing academic theory, and with this purpose they survey 336 financial directors. The authors find in their study that the most important motivation for the CFOs in the going public decision is to facilitate acquisitions and that traditional explanations such as lowering the cost of capital are not among the three most relevant motivations for launching an IPO. In addition, the authors state that high-tech companies view the choice of going public as a strategic reputation-enhancing move and less as a financing decision and that the high-tech companies are more concerned about pricing issues and bad market than about control and dilution. When considering the timing of IPO, CFOs seem to ponder market and industry returns (Brau & Fawcett, 2006).

2.1.2. International insights

There are some studies that focus in provide international insights about public offers (Loughran, Ritter, & Rydqvist, 1994; Kim & Weisbach, 2008). Loughran et al. (1994) evidence that companies time their offerings for times in which valuations are high and that the level of IPO volume is negatively related to the market return of the subsequent year, in 10 of the 14 countries analyzed by the authors. Kim and Weisbach (2008) using a sample of 17,226 IPOs and 13,142 SEOs from 38 countries evidence that per marginal dollar of capital raised in a public offering the R&D expenditures increase by 18.5 cents in the first year subsequent to an IPO and 78.0 cents for the four-year period following IPOs, which suggests that raise external capital to finance investments is an important motive of the going public decision.

2.2. Underpricing

The magnitude of underpricing varies over time but does not show signs of having dissipated, on the contrary, which has attracted the attention of several researchers. In the second half of the 1990s, the stock market experienced unprecedented gains, powered by technology and internet companies. Most studies do not focus on high-tech companies but provide important insights that can be tested for the technology industry.

2.2.1. Some studies that evidence the existence of Underpricing

Ibbotson (1975) was among the first to document the empirical regularity of underpricing (his results evidence an average initial performance of 11.4 percent in common stocks offered to the public for the first time in the 1960s). According to Loughran and Ritter (2004) the average underpricing was 7% in the 1980s, doubled to about 15% during 1990-1998, jump to 65% during the dot-com bubble and revert to 12% during 2001-2003. Loughran and Ritter (2004) also show that the median age of an issuing firm in the 1980s and in the 1990s was 7 years and 8 years, respectively; before falling to 5 years during the dot-com bubble, and then rise to 12 years in the post-bubble. Aggarwal, Krigman, and Womack (2002b) state that in the late 1990s, a first day underpricing of 50% was common, mainly for internet firms. During 1990-1998 more than $27 billion was left on the table, representing more than three years of aggregate profits and in 1999, 117 IPOs doubled the price in the first trading day, with $37 billion left on the table (Loughran & Ritter, 2002). Ritter (2018b) on his website provides evidence that the 1,980 U.S. IPOs conducted over the period 2001-2018 achieved a mean first day return of about 14.3%.

Loughran et al. (1994) find evidence for underpricing in all the 25 countries for which they have data. Chambers and Dimson (2009) calculate underpricing over the very long-run and find that the underpricing average 3.80% in the period 1917-1945, between the two world wars, compared to 9.15% in the period 1946-1986, after the Second World War and the author states that this increase cannot be attributed to changes in the composition of firms.

2.2.2. Explanations of Short-run Underpricing

Some theories that try to explain the underpricing are based on asymmetric information.

Allen and Faulhaber (1989) assume that there is asymmetric information, being the company who best knows its prospects. They find that a good company may wish to signal its superior prospects and can use a low IPO quantity or price to do that. In this way, underpricing can be viewed as a credible signal that the company is good, because only the good companies can expect to recoup this immediate loss.

Chemmanur (1993) assuming that the insiders have private information about the prospects of their companies and that outsiders may engage in information production about the company with costs, concludes that high-value companies, having the knowledge that are pooling with low-value companies, use underpricing to induce outsiders to produce information, and this information production leads to a more accurate valuation of the company in the secondary market.

Brav and Gompers (2003) also assume that there are informational asymmetries and that the insiders of companies that are more associated with these asymmetries lock-up their shares during more time. According to the authors companies that are unprofitable, that have a higher amount of intangible assets, that have lower quality underwrites, and that are not venture capital-backed lock-up their shares for a longer period. The authors conclude that for these companies that lock-up the shares for a longer period or that lock-up a higher fraction of the shares, the underpricing is higher. Additionally, the authors find that both affiliated and non-affiliated analysts are more optimistic concerning the earnings forecasts around the end of the lock-up period.

Baron (1982) also assumes that there is asymmetric information, but in his theory the issuer is less informed than the underwriter. The author realizes that the company is not able to monitor the banker costless and states that the companies must compensate the underwriters for the use of their better information; consequently, the company should allow the underwriter to some underpricing.

In the model of Rock (1986) a group of investors have superior information relatively to all the other investors and relatively to the company. The author states that if the new shares are priced at the expected value, the group of investors with superior information withdraw from the market when bad issues are offered and crowd out the others investors when good issues are offered; consequently, according to the author, the issuer must price the shares at a discount to ensure that the uninformed investors purchase the shares. Keloharju (1993) in a study of 80 Finnish IPOs confirms the winner's curse hypothesis of Rock (1986).

Welch (1992) introduces the concept of "cascade" in which potential later investors imitate the earlier ones, ignoring their private information. In an informational cascade, according to Ritter and Welch (2002), investors try to judge the interest of the others and just request shares if they consider that the offering is hot. Pricing just a little too high increases the likelihood of a complete failure of the issuer, because investors abstain given that the other investors also abstain (Ritter & Welch, 2002).

Yung et al. (2008) predict that the asymmetric information problem is heightened during waves because the dispersion in quality is higher, which is consistent with higher levels of underpricing in those periods.

Lowry, Officer, and Schwert (2010) find that, in addition to underpricing, there is volatility in initial returns (the standard deviation of the initial returns during 1965-2005 was 55%) and find that this volatility fluctuates greatly over time, which evidence the difficulty that underwriters have in valuing IPOs. The authors state that there is higher pricing errors and more dispersion of initial returns when a larger fraction of high information asymmetry companies, like the young high-tech companies, goes public as well as during hot markets. Lowry et al. (2010) also believe that alternative methods, such as auctions, could provide more accurate price discovery and Derrien and Womack (2003) agree with them. The ability of auction mechanism to incorporate more information about the recent and past market conditions in the initial price leads to lower underpricing and lower variance of the initial returns (Derrien & Womack, 2003).

The model of Sherman and Titman (2002) evidence that when companies have a high need for price accuracy, more investors participate in the offer, and the underpricing is greater. The authors suggest that the pricing accuracy may be important especially for riskier companies, for those that expect to have relevant capital needs in the future and for the ones which operations are more sensible to aftermarket price volatility.

There are in the literature authors that report signalling theories to explain the underpricing.

According to Carter and Manaster (1990) greater returns are required when the proportion of informed capital participating in an IPO is higher. For the authors, the most prestigious underwriters only market IPOs of companies with lower risks, to maintain their reputations, and consequently, when a company choose a prestigious underwriter, it is providing a signal to the market. They also state that if a company is perceive as having less risk, then, there is less incentive to the investors to acquire information, and the number of informed investors is lower. Therefore, the authors conclude that there is a negative relation between the prestigious of the underwriter and the level of the IPO return.

Welch (1989) also presents a signalling model in which companies with high-quality underprice their shares in the time of the IPO in order to obtain a higher price at a seasoned public offering. On the other hand, according to Jegadeesh, Weinstein and Welch (1993) the evidence for the signalling hypothesis as one of the most important determinants of underpricing is weak. In fact, according to these authors, the role of the first day returns in predicting future seasoned equity offerings are similar as the returns after the first day.

Other theories of underpricing are based on managers' and underwriters' characteristics.

Chemmanur and Paeglis (2005) find that more reputable and better managers can convey the intrinsic value of their companies in a more credible way, consequently reducing the information asymmetry that their companies face in the public market. Companies with more reputable and higher quality managers have more reputable underwriters but lower underwriting expenses, greater institutional interest and lower levels of underpricing (Chemmanur & Paeglis, 2005).

Aggarwal et al. (2002b) believe that underpricing is caused by managers acting strategically to maximize their wealth. The authors believe that underpricing cause information momentum, catching the attention of analysts and of the media. Consequently, according to the authors, there are higher prices for the shares at the lockup expiration, the first moment in which the managers can sell their shares. In fact, the authors find that when the ownership of managers is higher, the first day underpricing is also higher, which leads to more research coverage, what, in turn, result in higher stock returns and insider selling at the lockup period. Aggarwal et al. (2002b) also state that the value of information momentum is more likely to be higher in hot markets and industries, like the internet-related companies.

Beatty and Ritter (1986) demonstrate two relevant propositions: that exists a positive and monotone relation between the ex-ante uncertainty regarding the value of the IPO and the expected underpricing; and that investment bankers enforce the underpricing equilibrium, because if the investment banker underprices too much or if it does not underprice enough, it will lose market share.

Schenone (2004) find that companies with a pre-IPO relationship with a prospective underwriter have lower underpricing levels than companies without such pre-IPO relation by about 17%.

There are also theories related to litigation risk and marketing costs.

According to Lowry and Shu (2002) companies that have a higher litigation risk underprice more their offerings compared to the others as a form of insurance and in turn this higher underpricing leads to a decreasing in the expected litigation costs by reducing the likelihood of lawsuit. Keloharju (1993) in a study of one market (Finnish market) where the legal liability hypothesis is not likely to have relevance on underpricing, found similar levels of underpricing, not supporting the argument of Lowry and Shu (2002).

Habib and Ljungqvist (2001) argument that companies can affect the level of underpricing through the marketing choices they make, like the choice of underwriter and the choice of the exchange to list on, and according to the authors the underpricing is a substitute of marketing costs. Demers and Lewellen (2003) evidence that underpricing is significantly associated with web traffic growth in the month after the IPO of internet companies. They also show that underpricing is associated with the media mentions in the month of IPO for a broader sample of IPOs. The authors conclude that there are marketing benefits related to underpricing, and these benefits are not only for the internet companies.

Brau and Pawcett (2006) find that for CFOs the most important reason of underpricing is to reward the investors for taking the risk of investing and that the second more relevant reason is the underwriters' desire to obtain the favour of institutional investors.

2.2.3. Studies of the dot-com bubble period

Many authors study the dot-com bubble period.

Abdou and Dicle (2007) investigate if all the risk factors included in the prospectus are determinants of the underpricing during the Internet bubble. They conclude that not all risk factors are considered relevant. Remarkably, the authors find a negative economic significance of two risk factors: the no existence of a prior market for the traded shares and the rapid technological changes.

Cervellati (2012) also analyse the dot-com bubble period, through a study of Tiscali, the most recognized Italian internet company in that period. His analyse evidence an excess of optimism of analysts, caused by behavioral biases and potential conflicts of interest. The author also show that investors behaved irrationally, with investment decisions not based on the fundamentals of the companies and influenced by the great euphoria on the internet sector.

Ljungqvist and Wilhelm (2003) also study the period of the dot-com bubble and they argue that "both price revisions and underpricing during the dot-com bubble, although profoundly aberrant from a historical perspective, can be at least partially explained by equally profound changes in pre-IPO ownership structure and insider selling behavior" (p. 725). Gondat-Larralde and James (2008) derive an IPO pricing rule and also believe that tech IPOs were not excessively underpriced during the bubble.

Aggarwal, Bhagat and Rangan (2009) find that 20% of IPO companies had negative earnings during 1986-1990, while during 1999 this value increases to 80% and during 2000 also increases to 85%. Schultz and Zaman (2001) also find that the number of Internet companies that became public from January 1999 to March 2000 was 321 and only 28 had profits in the preceding quarter. Aggarwal et al. (2009) evidence that companies with more negative earnings have higher valuations relative to the companies that have fewer negative earnings and suggest that these negative earnings are a proxy for growth opportunities for internet companies.

Derrien (2005) starts to evidence that many of the 803 U.S. IPOs of the period 1999-2000 have been delisted or become "penny stocks", which evidence that these shares are overpriced. In fat, the author believe that issuers are not upset about underpricing because they know that the shares are overpriced at the time of the IPO.

Guo, Lev, and Shi (2006) identify the research and development (R&D) activities of companies as the major contributor to IPO uncertainty of science-based and technology companies. They show that the pre-IPO intensity of the R&D activities of the companies is positively and significantly related to underpricing.

2.2.4. Underpricing and Allocation

Existing literature has increasingly focused on understanding how IPOs are allocated and many theories of underpricing are based on some factors related to the allocation process.

According to Benveniste and Spindt (1989) underpricing arises naturally to compensate investors with favourable information about the value of the IPO for truthful disclosure of their own information. Hanley (1993) also finds that when regular investors reveal truthfully good information through demand, they are compensated with an increase in the underpricing and in the share allocation. Consequently, the author states that when companies go public at a price above the anticipated range, the issues have significantly more underpricing compared to the others. In fact, Hanley (1993) calculates a 20.7% average initial return for issues with a price above the anticipated range, 0.6% for the ones with a price below the anticipated range and 10.0% for offerings within the anticipated range.

Loughran and Ritter (2002) justify the underpricing as being an indirect way of underwriter compensation, because investors are disposed to offer such compensation to gain favourable allocations on hot deals. However, the underpricing is an indirect cost for the company that is issuing the offering, and the companies agree with such underpricing only when they are, at the same time, receiving good news in the form of unanticipated increases in the wealth (Loughran & Ritter, 2002).

Stoughton and Zechner (1998) focus on the agency problem that arises when the only investors capable of monitoring the company are the large institutions while the small investors free-ride on such activities. The authors believe that the underpricing is necessary to motivate the acquisition of a block of shares and the monitoring of the company. They also state that for companies that have a higher benefit-to-cost ratios for monitoring activities, like the case of high-tech companies, the underpricing should be greater.

Booth and Chua (1996) evidence that, in the presence of costly information, underpricing is a positive function of ownership dispersion. Pham, Kalev and Steen (2003) also study the relation between underpricing and a more diffuse ownership structure. They find that liquidity is a partial but relevant benefit of underpricing. Ellul and Pagano (2006) find that liquidity risk and expected after-market liquidity are important determinants of underpricing, with the underpricing being larger when the liquidity is less predictable and when the aftermarket is expected to be less liquid.

According to Sherman (2000) an important difference between book building method and the others is that, with this method, the underwriters have total discretion in allocating shares, which permits that the allocations are based on long term relationships between the investors and the underwriters. The author shows that the capacity of the underwriter to reduce the level of the underpricing are greatly dependent on its capacity to favour regular uninformed investors.

Using a sample of 69 IPOs in the UK, Brennan and Franks (1997) evidence that underpricing is used to guarantee oversubscription and therefore permit the rationing in the share allocation process allowing owners to discriminate among applicants for shares and to reduce the block size of new investors. The authors also find that a higher level of underpricing is associated with smaller blocks being held by new shareholders seven years after the offering and that in the period of up to ten years after the offering, there is a low level of hostile takeovers, which is consistent with the idea that the insiders protect themselves against hostile changes of control.

Ljungqvist and Wilhelm (2002) reach four important conclusions. The first one is that allocation policies favour institutional investors around the world. They also conclude that increases in institutional allocations result in offer prices that deviate more from the initial price range and that constraints in the underwriter's discretion reducing institutional allocations result in smaller price revisions, which evidence a lower information production. The authors also conclude that underpricing is positively related to information production and negatively related to institutional allocations, which indicate that discretion allows the minimization of the wealth losses of the issuer. In contrast, Aggarwal, Prabhala, and Puri (2002a) find a positive relation between institutional allocation and underpricing. One of the explanations provided by the authors to their finding is that underwriters allocate more shares to institutional investors in issues that are more likely to have higher level of underpricing, as a quid pro quo for obtaining in the premarket favourable demand information. Hanley and Wilhelm (1995) also find that institutions are favoured, capturing a large fraction of the short-run returns.

Gondat-Larralde and James (2008) find great support for the conjecture that underwriters preferentially allocates shares to their coalition and Cornelli and Goldreich (2001) find evidence that the underwriter awards more shares to the investors that provide more information in their bids and to regular investors.

Loughran and Ritter (2004) argue that there are two reasons for companies have been more complacent to leave money on the table in the 1990s and in the dot-com period: the analyst coverage became a more relevant factor for companies in the choice of the underwriter and the allocations of hot IPOs to the personal brokerage accounts of the executives of the issuing company, which created a motivation to seek and not to avoid underwriters with a reputation for great underpricing. Cliff and Denis (2004) also believe that underpricing is, in part, a recompense for expected post-IPO analyst coverage.

2.3. Long-run Performance

Many authors find that IPOs underperform over the long-run. Ritter (1991), for example, using a sample of 1,526 IPOs in 1975-1974, find that the average holding three-years return is 34.47%, while a control sample of also 1,526 listed stocks, matched by market value and industry, produces over the same three years holding period an average total return of 61.86%, therefore it is predicted that IPOs in the long run underperform by about 27.39%. The author also finds that younger companies and companies that go public in heavy volume years underperform even more than the others. Loughran et al. (1994) find evidence of long-run IPO underperformance in the 9 countries for which they have data.

2.3.1. Long-run Underperformance Theories

There are some studies that try to explain this phenomenon.

Eckbo and Norli (2005) do not reject the hypothesis that the expected return on IPO stocks is adequate given the portfolio's risk exposures. In fact, the authors evidence that IPO companies have low leverage and high stock turnover and therefore are less risky.

Houge, Loughran, Suchanek, and Yan (2001) conclude that the divergence of opinion among investors provide significant predictive power to explain poor long-run IPO returns. For example, each one percent increase of opening spread, which is a measure of uncertainty and divergence of opinion, leads to a decrease in the one-year excess returns by 1.2 percent.

Teoh, Welch, and Wong (1998) find that companies with higher discretionary accruals experience poor performance in the three years following the IPO.

The model presented by Chemmanur and He (2011) predicts that companies that decide to go public during an IPO wave will have lower post-IPO profitability and lower productivity than those companies that decide to go public off the wave.

Guo et al. (2006) find that the long-run performance only occurs for no-R&D IPOs and justify this conclusion as a manifestation with the excess of investor optimism for no-R&D IPOs while the IPOs of R&D-intensive companies are less prone to investor optimism.

2.3.2. Some studies that do not support the existence of Underperformance

Some other authors do not believe in the existence of long-run underperformance of IPOs.

Brav and Gompers (1997) find that venture-backed companies do not significantly underperform, but the smallest nonventure-backed companies do. However, according to the authors, this underperformance seems not to be an IPO effect, given that similar book-to-market and size companies that are not public perform as poorly as the ones that decide to go public. The authors argue that the underperformance of these small and low book-to-market companies can be caused by, among other factors, investor sentiment, given that the smaller companies are held primarily by individuals and therefore are the ones more likely to be subject of fads and investor sentiment.

Gompers and Lerner (2003) examine the performance of IPOs using data of a period before the formation of NASDAQ and conclude that the results depend considerably on the method of return measurement that is used. For example, when cumulative abnormal returns are used, there is no underperformance of IPOs.

The long-run underperformance of IPOs is one of the most controversial topics related to IPOs.

3. Methodology and Sample

3.1. Methodology

As mentioned earlier, our research questions are: which are the financial and non-financial underpricing value drivers of high-tech companies in the period 2001-2019 and what is the long-run performance of high-tech IPOs compared to other high-tech companies and compared to all companies.

To answer each of our two research questions, different methodologies are employed.

3.1.1. Underpricing

3.1.1.1. Regression

We estimate the following regression:

$$Underpricing_i = \alpha + \beta_1 R\&D(-1)_i + \beta_2 R\&D(-2)_i + \beta_3 Intangible(-1)_i + \beta_4 Lagged_i + \beta_5 Volatility_i + \beta_6 SEO_i + \beta_7 NetIncome_i + \beta_8 \ln(1 + age)_i + \beta_9 \ln(Size)_i + \varepsilon_i$$

The dependent variable is $Underpricing_i$, the first day return for each IPO i, calculated for each one as follows:

$$Underpricing = \frac{First\ day\ closing\ price - Offer\ price}{Offer\ price}$$

The independent variables are:

$R\&D(-1)_i$ is the expense on Research and Development incurred by the IPO firm i in the last fiscal year before the IPO;

$R\&D(-2)_i$ is the expense on Research and Development incurred by the IPO firm i in the penultimate fiscal year before the IPO;

$Intangible(-1)_i$ is the Total Intangible Assets in the last fiscal year before the IPO;

$Lagged_i$ is the lagged underpricing of the last last 6 months for each IPO i; it means, for each IPO we calculate the average underpricing of the other firms that conducted their IPO in the last 6 months;

$Volatility_i$ is used as a proxy of uncertainty regarding each IPO i, calculated using the following formula:

$$\frac{High\ Price\ in\ the\ first\ day\ of\ trading - Low\ Price\ in\ the\ first\ day\ of\ trading}{\frac{High\ Price\ in\ the\ first\ day\ of\ trading + Low\ Price\ in\ the\ first\ day\ of\ trading}{2}}$$

SEO_i is the weight of the total size of Secondary Public Offerings held within 3 years after the IPO compared to the amount of the initial offer size;

$NetIncome_i$ is the Net Income in the last fiscal year before the IPO;

$LN(1+age)_i$ represents the natural logarithm of the age of each firm i at the time of the IPO;

$LN(Size)_i$ is the natural logarithm of the offer size for each IPO i.

The variables related to Research and Development expenses (R&D(-1) and R&D(-2)) were included given the work of Guo et al. (2006) that show that the pre-IPO intensity of the R&D activities of the companies is positively and significantly related to underpricing. The variable Intangible(-1) was included because we consider that it may be a proxy for accumulated R&D investment.

The variable Lagged was included due to the study of Bradley and Jordan (2002) that evidence a positive and strong relationship between underpricing and lagged underpricing.

Given the work of Welch (1989), who presents evidence that underpricing is related to the desire of obtain a higher price at a seasoned public offering, the variable SEO_i is used.

Aggarwal et al. (2009) evidence that companies with more negative earnings have higher valuations relative to the companies that have fewer negative earnings, as already mentioned in our literature review, and these authors also suggest that the negative earnings are a proxy for growth opportunities for internet companies, hence the inclusion of the variable NetIncome.

The natural logarithm of offer size was used in light of the work of Booth and Chua (1996), with the difference that in their work the offer size is expressed in terms of 1994 purchase power, whereas we use current prices. The natural logarithm of age was used in light of the work of Ljungqvist and Wilhelm (2003).

Additionally, we conduct a series of univariate analyses for some of the variables mentioned above.

3.1.2. Long-run Performance

We attempt to replicate the works of Ritter (1991) and Brav and Gompers (1997) and add as much value as we can to the industry we are studying.

3.1.2.1. Event Time Results

First, as in Ritter (1991) we calculate 3-year buy and hold returns, it means, the total return from a buy and hold strategy where a stock is purchased at the end of the first trading day after the IPO and is held for three years (or until the delisting date or until June 2019 if any of these moments occur before the IPO's third anniversary).

The 3-year buy and hold return of each IPO is calculated differently depending on whether or not the company has distributed dividends during these three years.

In the case of companies that did not distribute dividends, the 3-year Post-IPO return is calculated as in Ritter (1991):

$$\left(\frac{\text{Price on the 3−year anniversary}}{\text{First closing market price after the IPO}} - 1\right) * 100\%$$

For those who distributed dividends, the monthly return was calculated as follows:

$$\left(\frac{\text{Price at the end of the month + Dividends}}{\text{Price at the beginning of the month}} - 1\right) * 100\%$$

In the case of the first month of trading, the price at the beginning of the month corresponds to the first day close price, and in the 36th month (or in the month of the delisting date, if it occurs earlier) the price at the end of the month is replaced by the price at the end of the day of the third anniversary of the IPO (or the price at the end of the day of the delisting date, accordingly).

After calculating the monthly return for each of the 36 months after the IPO, the 3-year return is obtained on compounding monthly returns for 36 months. If the IPO is delisted before the 36th month we compound the return until the delisting date or, in the case of the most recent IPOs in our sample that have not yet completed three years since the IPO, we compound the return until June 2019.

However, when we are measuring the long-run performance of IPOs we should not only look at their absolute performance, but also to their relative performance, it means, abnormal returns relative to different benchmarks.

Thus, our 3-year equal weighted returns on IPOs are compared with four benchmarks throughout our work: first, as in Brav and Gompers (1997), the performance of our IPO firms is matched to three broad market indexes: the Nasdaq Composite, the S&P 500 Composite, and the NYSE Composite (all of which include dividends). Additionally, since we are studying high tech companies, we also compare our IPO portfolio with the Nasdaq-100 Technology Sector Index, an equal weighted index whose constituents are the securities of the Nasdaq-100 Index[1] that are classified as Technology.

The return of each benchmark was calculated for several different periods, corresponding to the same period for which the returns of each IPO are calculated

Then, as in Ritter (1991) and Brav and Gompers (1997), the Wealth relatives are calculated as follows:

$$\frac{\sum(1+3-year\ buy\ and\ hold\ return\ of\ each\ IPO)}{\sum(1+3-year\ buy\ and\ hold\ return\ on\ the\ benchmark\ over\ the\ same\ period)}$$

Basically, the numerator of this equation is the average 3-year total return on IPOs and the denominator the average 3-year total return on the benchmark that is being compared.

A Wealth relative of greater than one mean that the IPO portfolio is outperforming relative to its benchmark and a Wealth relative of less than one indicates that IPOs has underperformed relative to its benchmark.

3.1.2.2. Calendar Time Results

The event time results that we will present according to the methodology described above, according to Brav and Gompers (1997, p. 1803) "may be misleading about the pervasiveness of underperformance. Cohort returns (…) may overstate the actual number of years in which IPOs underperform because the returns of recent IPO firms may be correlated." According to the same authors, if a shock in a given year, for example 2013,

[1] Nasdaq-100 is a stock index whose constituents are 100 of the largest non-financial companies listed on the Nasdaq Stock Exchange.

decreases the value of the companies that carried out their IPO, it affects the cohort years from 2009 to 2013, although all underperformance is concentrated only in 2013.

Therefore, to address this correlation, we calculate the monthly return on portfolios constituted by an equal amount of all IPO firms of our sample that went public within the previous three years. Thus, the return for each month is equal to the average return of our sample stocks that were not listed for more than 3 years at the end of that month. For example, the return for December 2016 is equal to the average return of companies that made their IPO between January 2014 and December 2016. On the other hand, a company that made its IPO in January 2015, for example, will count to the calculations of monthly returns between January 2015 and December 2017.

Then, such as Brav and Gompers (1997), the annual return is calculated by compounding monthly returns on the IPO portfolios from January to December of each year. The only exceptions are 2001, where the annual return is calculated by compounding monthly returns from February to December, since we have no IPO in our sample in January 2001, and 2019, where we only have data until June.

These calendar time returns are compared with the four benchmarks. The annual benchmark returns are also calculated by compounding monthly returns for the same period.

3.1.2.3. Fama-French (1993) Three Factor Model

According to Brav and Gompers (1997), if IPOs under analysis underperform on a risk-adjusted basis, then portfolios of IPOs should underperform relative to an explicit asset pricing model consistently. According to the same authors, the three factor model of Fama and French (1993) may explain the cross section of the returns.

$$R_{pt} - R_{ft} = \alpha + \beta_t \left(R_{mt} - R_{ft}\right) + s_t SMB_t + v_t HML_t + \varepsilon_{pt}$$

The dependent variable in this model is the monthly return on portfolios constituted by an equal amount of all IPO firms of our sample that went public within the previous three years, as explained before. R_{pt}-R_{ft} is the excess return over the risk-free rate on a portfolio in period t. The three factors of Fama and French (1993) model are: R_{mt}-R_{ft}, which is the excess return on the value weighted market portfolio in month t; SMB_t, small minus big, the difference between the return on a portfolio of small stocks and the return on a portfolio of big stocks in period t, and HML, high minus low, the return on a zero investment portfolio calculated as the difference of return on a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks in period t, for other words, it is calculated by subtracting the return on a portfolio of growth stocks from the return on a portfolio of value stocks.

The dependent variable is calculated by us, as already mentioned; the risk-free rate in month t (R_{ft}) is the one-month Treasury bill rate and the three factors of Fama and French (1993) model were taken from the Data Library of Kenneth R. French (French, 2019).

The regressions use 221 observations when the sample period is from February 2001 to June 2019. In the regressions in which we add the lagged Fama-French factors, the number of observations is 220, from March 2001 to June 2019.

According to the works of Brav and Gompers (1997) and Ritter and Welch (2002), the intercept from the time series regressions is used as an indicator of risk-adjusted performance, it is a measure of abnormal performance. According to Brav and Gompers (1997) this intercept has an interpretation similar to Jensen's alpha in the Capital Asset Pricing Model framework, but with the advantage that it is possible to make statistical inferences given the assumption of multivariate normality of the residuals and with the disadvantage of give the same weight to each month in minimizing the sum of squares. That is, the first months of 2001 (the average of a small number of IPOs) have the same weight as the final months of 2007 (the average of a large number of IPOs); therefore the results of this model may reduce the measured underperformance if underperformance is correlated with the number of firms in the portfolios.

Like in the work of Brav and Gompers (1997) we also sorted the sample on the basis of size. Every month we divide our sample of IPOs into three size portfolios (an equal number of stocks are allocated to each tercile) based on the previous month's market capitalization using all IPOs to determine the breakpoints. In the first month of trading, as there is no market capitalization from the previous month, we use the offer size. The portfolios are rebalanced monthly and IPOs are allowed to switch portfolios every month. Portfolio returns are the equal weighted returns for IPOs within each size group.

Brav and Gompers (1997) rerun the three factor regressions of Fama and French (1993) including an index that measures the change in the average discount on closed-end funds.

Lee, Shleifer, and Thaler (1991) argue that the average discount on these funds reflects the relative level of investor sentiment. The idea is that when the average discount decreases, that is, when the change in discount is negative, investors may be more optimistic and consequently returns from firms affected by this investor sentiment should rise. Inversely, when the average discount increases, the change in discount is positive, individual investors may be more pessimistic and returns should fall (Brav & Gompers, 1997). Then, the purpose of this procedure is to ascertain whether the investor sentiment could be an important source of underperformance.

We, like Brav and Gompers (1997), construct the index as in Lee et al. (1991). The Value-Weighted Index of Discounts (VWD) is calculated at the monthly level as follows:

$$VWD_t = \sum_{i=1}^{nt} (W_i * \mathrm{DISC}_{it})$$

We value weight the discount across closed-end funds in a given month. In turn, the discount on a fund is the difference between the net asset value of the fund and its price divided by the former:

$$\mathrm{DISC}_{it} = \frac{\mathrm{NAV}_{it} - \mathrm{SP}_{it}}{\mathrm{NAV}_{it}} * 100$$

NAV_{it} is the net asset value of closed-end fund i at end of month t, and SP_{it} is the stock price of the closed-end fund i at end of month t.

The Net Asset Value (NAV) per share at the end of the month combined with the number of outstanding shares at the end of the same month allow us to calculate the total Net Asset Value for each fund. Thus, the weight of each fund is given to us by:

$$W_i = \frac{\mathrm{NAV}_{it}}{\sum_{i=1}^{nt} NAV_{it}}$$

Then, we calculate the change in the average discount on funds from the end of last month to the end of this month, as follows:

$$\Delta Discount_t = VWD_t - VWD_{t-1}$$

The number of funds with available data at the end of month is called n_t[2]. We have information on 454 closed-end funds (we excluded bond funds, like Lee et al. (1991)). All of these funds were active as of June 2019 but not all of them existed as of January 2001. Then, the stock closed-end fund ΔDiscount series had monthly memberships ranging from 67 to 454 funds.

3.1.2.4. Summary

There are some criticisms of underperformance testing, whether we use the multifactor model or other procedures, and Ritter and Welch (2002) argue that these tests should not be viewed as tests of mispricing of the IPOs but rather as tests of similarity to some public companies. Some authors highlight some problems with these tests: the long-run returns are sufficiently noisy to make any statistical inference difficult (Ritter and Welch (2002); there is a bias in the three-factor model of Fama and French (1993), identified by Loughran and Ritter (2000): is that the factor returns of Fama and French are themselves partly composed of returns on IPOs; another bias is that the Fama and French (1993) regressions tend to have negative intercepts when portfolios consist of small growth firms, regardless of portfolio being composed by IPOs or not (Brav & Gompers, 1997); tests of underperformance suffer from the joint hypothesis problem (Fama, 1976; Brav & Gompers, 1997); another problem identified by Brav and Gompers (1997) is the nonstandard distribution of long-run returns. Ritter and Welch (2002) go further and claim that the asset-pricing literature is not yet able to provide an acceptable model of risk-adjusted performance against which we can measure post-IPO performance. Ritter and Welch (2002) are among the authors who argue that the magnitude of long-run abnormal performance is sensitive to the sample period and to the methodology.

We employed several procedures, so we believe our results are robust enough that we can draw some conclusions about the long-running performance of the tech IPOs in the longest possible period after the internet bubble: from 2001 to 2019. As it is a long period, we also look at subperiods, again with the intention of providing as accurate and thorough information as possible.

[2] Information obtained from *Datastream* database.

3.2. Sample Selection

In order to answer to our research questions, our sample includes all technology Initial Public Offerings (IPOs) conducted between January 2001 through April 18, 2019, on U.S. exchanges, according to IPOScoop.com research site.

To consider a company as technological, we use the same classification as Loughran and Ritter (2004). Thus, stocks of companies belonging to the following SIC codes are defined as tech stocks: 3571, 3572, 3575, 3577, 3578 (computer hardware), 3661, 3663, 3669 (communications equipment), 3671, 3672, 3674, 3675, 3677, 3678, 3679 (electronics), 3812 (navigation equipment), 3823, 3825, 3826, 3827, 3829 (measuring and controlling devices), 3841, 3845 (medical instruments), 4812, 4813 (telephone equipment), 4899 (communications services), and 7371, 7372, 7373, 7374, 7375, 7378, and 7379 (software). The SIC code 7370 (services-computer programming) was also used to classify a company as technology, as this SIC code was defined in the initial list of the same authors (Loughran & Ritter, 2001). SIC codes 3559, 3576, and 7389 have been added, as Ritter on his website uses the same procedure (Ritter, 2018a).

Once we define the SIC codes that dictate whether a company is considered a technology company or not, we need to know which SIC code of each company. For this, we took the initial list of IPOs obtained through the aforementioned IPOScoop.com research site and, for each company, was manually searched for its SIC code. The prime source for each company's SIC code is Form S-1 (also called prospectus), the initial registration form for all companies planning to go public and to register their securities with the Securities and Exchange Commission (SEC). The Form S-1 is the best source to find out which industry of the company is doing its IPO, because it allows us to find out which SIC code at the time of the IPO. Other sources of information may not give us the SIC code at the time of the IPO, but at a later time. Given that companies can change industry over time, using a source other than Form S-1 is not the ideal situation. However, in cases where Form S-1 is not readily available, the SEC website was used to check each company's SIC code (Securities and Exchange Commission, 2019). Ultimately other databases were also used, such as Orbis from Bureau van Dijk, *Datastream* database from Thomson Reuters and the Nasdaq website. In the case of companies with the SIC code 7389 (business services), its business description was also consulted to ascertain its technological nature.

After the process of manually collecting the SIC code of each firm, we obtained the list of technology companies that conducted their IPO in the period under review, but we further eliminate the American Depositary Receipts (ADRs), as in Loughran and Ritter (2004), Ljungqvist and Wilhelm (2003), and Ritter and Welch (2002).

After ensuring that each of the selected companies is followed by *Datastream* database, we get our final sample. Our final sample consists of 603 firms.

3.3. Data

From the IPOScoop.com research site in addition to the issuer and date of each IPO, we obtained for each of our observations the following information: lead/joint-lead managers, offer price, opening price and first day close price (IPOScoop.com, 2019).

From the Nasdaq website we obtained data related to: the stock exchange in which the firm will place its shares, the offer price of each share in the IPO, the number of shares in the initial offer (NASDAQ, 2019a), and, in the cases where the firms made a secondary offering (SEO) after the IPO, information was also obtained related to the date of the secondary offering, the offer price and the number of shares issued (NASDAQ, 2019b).

From *Datastream* database, and for each firm, the following information was obtained: date of incorporation; equity status; inactive date (in the case of the equity status of the company be inactive); price quote from IPO to 3 years after; dividend information from IPO date to 3 years after; turnover rate; intraday high price and intraday low price from IPO date to the end of the civil year; net sales or revenues, total assets, common shareholders equity and net income in the last fiscal year before the IPO; long-term debt, interest expense on debt, total intangible of assets (net), net assets from acquisitions, capital expenditures, capital expenditures as % of total sales, research & development, research & development as % of total sales, total debt and net debt for the years between two years before the IPO and two years after. It was also taken from the same database the quotes of Nasdaq composite, S&P 500 composite, NYSE composite and NASDAQ 100 tech sector indices since 2001. Finally, from *Datastream* database we also obtained data related to closed-end funds: net asset value per share, number of shares and price for each closed-end fund followed by *Datastream* database since 2001 to June 2019.

The Fama and French (1993) 3 research factors (for U.S.) were taken from the French Library (French, 2019).

4. Activity

When firms decide to do an IPO it is because they have one or several motivations to do so. In many cases, the reason may simply be that of raising equity capital, but even when that is the main reason, the question arises as to why IPOs are the best way to achieve the goal of raising capital. Several pros of putting up a public company can be pointed out, such as increasing its visibility, but we can also easily find some cons, such as the complexity of public markets.

In this section we present some descriptive characteristics of the IPOs in our sample and some descriptive characteristics related to the Issuers that conduct those IPOs and we try to show, with some simple calculations, whether our data provides some support or not to some theories about the going public decision.

4.1. Evidence

Looking at Table 1, we can see that the number of technology companies conducting their IPO is very different from year to year, with only 4 companies conducting their IPO in 2008, when in the previous year the number had been 68 (exactly 17 times more). If we focus on gross proceeds, we see that the amount of proceeds were higher in 2012 (about \$20,411 million) than in the previous four years together (about \$17,922 from 2008 to 2011). These numbers raise questions about why in some years, or at certain times, there are more motivations to do an IPO than at others.

If we look at the works of other authors studying IPOs from all industries, and not just technology IPOs, we can see that they get similar conclusions. Gompers and Lerner (2003) analysing the period 1935-1972 show that the number of IPOs that occurred in the U.S. over a 25-year period from 1935 to 1959 is 630, lower than the number of IPOs that occurred in a single year, the year of 1969, with 683. Ritter and Welch (2002) analyse the period from 1980 to 2001, and find that while in 1996 there were 621 IPOs in the U.S., in 2001 only 80 companies made the decision to go public.

The Gross Proceeds and Money left on the table values shown in Table 1 correspond to nominal values. The average and median values of these two headings over the years can be found in Appendix A.

Table 1 - Number of IPOs, Aggregate Gross Proceeds, First day Returns, and Amount of Money Left on the Table, by Cohort Year, 2001 to 2019[3]

This table presents some descriptive statistics of our sample IPOs. The aggregate gross proceeds is the sum of the gross proceeds of all IPOs under analyse over a given period. The gross proceeds of each IPO are equal to the amount raised from investors in the offering, it means it is equal to the offer price times the number of shares issued. The first day return is calculated for each IPO as the difference between the first day closing price and the offer price divided by the offer price. The mean first day return (also called mean underpricing) is the equally weighted average first day return of the IPOs we are analysing. We also calculate this average with the proceeds weighted: it is the ratio of the aggregate money left on the table to the aggregate gross proceeds. In turn, the aggregate money left on the table is the sum of the amount left on the table by all IPOs under analyse. For each IPO, this value is calculated as the difference between the first day closing price and the offer price multiplied by the number of shares issued. Our sample comprises the 603 high-tech IPOs conducted between 2001 and 2019 (ADRs have been excluded). The aggregate gross proceeds and the aggregate money left on the table were calculated taking into account 601 IPOs, due to lack of information. Information related to the offer price and first day closing price is from IPOScoop.com research site and the number of shares issued is from the Nasdaq website.

Year	Number of IPOs	Aggregate Gross Proceeds, $ Millions	First day Return			Aggregate Money Left on the Table, $ Millions
			Mean First day Return	Mean First day Return (Proceeds-weighted)	Median First day return	
2001	24	6,970	22.0%	6.9%	15.5%	484
2002	20	2,616	8.8%	6.6%	10.6%	172
2003	14	1,751	23.5%	15.2%	26.0%	267
2004	59	8,412	13.8%	16.0%	6.9%	1,347
2005	42	6,317	8.8%	6.9%	4.0%	433
2006	46	5,738	14.4%	15.4%	12.7%	886
2007	68	10,785	18.9%	24.9%	14.0%	2,684
2008	4	887	-4.4%	-8.8%	-6.6%	-78
2009	15	4,347	16.8%	18.1%	13.2%	787
2010	35	5,079	10.7%	5.6%	7.5%	283
2011	30	7,609	21.3%	23.3%	18.5%	1,774
2012	35	20,411	19.9%	7.1%	16.7%	1,445
2013	34	6,828	27.9%	38.1%	27.6%	2,604
2014	50	8,843	23.4%	20.5%	15.2%	1,817
2015	32	7,895	17.0%	13.6%	12.9%	1,073
2016	21	2,475	29.6%	33.7%	24.0%	833
2017	28	6,704	21.9%	34.4%	18.6%	2,309
2018	38	9,719	31.2%	32.7%	31.9%	3,174
2019	8	4,955	47.2%	28.3%	47.9%	1,404
Total	603	128,340	19.2%	18.5%	13.8%	23,697

4.2. Brief discussion of some theories

Although not one of the main questions we want to answer in this paper, understanding the motivations behind the decision to conduct an IPO is important in any study that addresses this topic, and our work is no different. However, it is not easy to test the various theories we have outlined in our literature review related to IPO activity, because some theories are theoretical, others require inaccessible information, and by using a sample of companies that have done their IPO we would be ignoring those who did not, and to

[3] It should be noted that the 2019 data only includes IPOs conducted until April 18.

prove the reasons for a company to make a decision such as going public, it is equally important to understand the reasons for those companies that choose not to. However, and very broadly, we briefly summarize the theories that appear to be most likely or less likely, according to our sample and data.

The work of Kim and Weisbach (2008) evidence that for every dollar raised in the offering, Research and Development (R&D) and Capital Expenditures (CapEx) increase by 18.5 and 9.9 cents, respectively, in the year after the date of the IPO. Our sample, according to the research of those authors, also shows that firms spend substantial amounts on R&D and CapEx. The amount each company in our sample spend on R&D and CapEx in year n (IPO year) is, on average, 25.5% and 11.9%, respectively, of the amount raised in the IPO. Our data also shows that R&D and Capital Expenditures increase in the year following the IPO by 6.2 cents and 3.1 cents, respectively, and by about 12.5 cents and 8.1 cents, respectively, in the two years following the IPO. Therefore, raising money to finance new projects or investments seems to be a reason to conduct an IPO.

Schultz and Zaman (2001), as mentioned in our literature review, find evidence that companies become public to grab market share, showing that internet firms acquire other companies and form strategic alliances at a much higher rate than others. We conduct a brief exercise in analysing the change in net assets from acquisitions from year n (IPO year) compared to year n-1 (year prior to IPO year). We have information about this heading in these two years for 520 companies. Of these 520, 314 have the zero heading in both years, 123 have the highest heading in year n than year n-1 and 83 companies have a reduction in the value of this heading from year n-1 to year n. For the 123 companies that see the value of this heading vary positively from year n-1 to year n, the average growth rate of the item is 10635%. So our simple exercise seems to show that some companies may in fact see the possibility of grab market share as one of the reasons for making an IPO, although it does not seem to be a reason for all of them.

Lowry and Schwert (2002), as already mentioned, show that high underpricing values lead to an increase in the number of IPOs by about six months. In fact, looking at our data, we found that only 1 of our 603 IPOs were conducted at a time when the average underpricing for the past 6 months was negative and only 2 of the IPOs were conducted at a time when no high tech IPOs had been performed in the last 6 months. 75 IPOs were performed in a period where the average underpricing of the last 6 months was between

0% and 10%, 120 were made in a period when the average underpricing of the last 6 months was between 10% and 15% and the remaining 405 companies were conducted at a time when the average underpricing of the last 6 months was over 15%. Consequently, our sample does not reject the idea of authors such as Lowry and Schwert (2002) and Yung et al. (2008) that there is a correlation between volume and underpricing of IPOs.

4.3. The Composition of IPO Issuers

Table 2 shows the mean and median values of some variables that characterize the issuers. The data presented concerns to the nominal values of the last fiscal year before the IPO.

Since 2012, the median Issuer in terms of Common Shareholders Equity shows a negative value in this heading, which was not the case from 2001 to 2011. The median, when we analyse Net Income, only shows positive values in two years: 2008 and 2009, precisely the two years in which the number of IPOs was lowest among the years under review. The percentage of IPOs with negative or zero net income also seems to be increasing, albeit not linearly: while from 2002 to 2012 this percentage has not reached values above 63%, since 2013 the lowest recorded value was 69.7%.

The median age of our sample firms in the date of the IPO is about 6.8 years, in line with the results of Loughran and Ritter (2004), which show that the median age of Issuers was notably stable at around 7 years between 1980 and the period of the Internet bubble (Ritter & Welch, 2002). However, it should be noted that while the median age of IPO Issuers was no more than 7 years in any year from 2001 to 2010, the median age has been recurrently above 7 years since 2011; what seems to show that, in recent years, technology companies carry out their IPO at a later stage.

4.4. Summary

The number of technology companies conducting IPOs is not equal from year to year, by contrast, which raises the debate about why companies choose to go public and why these reasons seem to be more important at certain times than they are in others. It is not easy to test the theories presented on this topic, but we have conducted a brief exercise to test some, more quantitative, with our data, and the fact is that we offer some support for them: the companies in our sample increased their R&D expenses and CapEx in the years following the IPO, grab market share may be one of the reasons why some firms decide to do an IPO, and the majority of our firms conducted their IPO at a time when the average underpricing of the last 6 months was over 15%.

Table 2 – Mean and Median of Net Sales or Revenues, Total Assets, Common Shareholders Equity, and Net Income, fraction of IPOs with negative Net Income and Median Age of the Issuers, for the last fiscal year before the IPO date

This table presents some descriptive characteristics of the sample firms. Our sample comprises the 603 high-tech firms that conducted their IPO between 2001 and 2019. We have information about net sales or revenues for 565 companies, about total assets and common shareholders equity for 561 companies and about net income for 563 companies. These accounting data is from *Datastream* database and refer to the last fiscal year before the IPO. The age of each issuer is the number of years the company had at the time of the IPO, in other words age is IPO date minus date of incorporation. The information related to IPO date is from IPOScoop.com research site and the data regarding the date of incorporation is from *Datastream* database. We have information about age for 465 companies.

	Net Sales or Revenues, $ Millions		Total Assets, $ Millions		Common Shareholders Equity, $ Millions		Net Income, $ Millions			
Year	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Percentage of IPOs with Net Income <=0	Median Age
2001	268	23	801	87	458	61	-19	-13	84.2%	5.2
2002	458	128	139	142	60	75	-34	-5	58.8%	6.0
2003	101	79	169	151	64	102	1	0	53.8%	7.0
2004	174	39	230	86	169	63	-6	-2	63.0%	6.9
2005	117	67	272	92	71	56	-5	-3	57.1%	5.9
2006	252	43	260	89	90	44	9	0	50.0%	6.2
2007	250	68	404	147	122	90	-3	-4	60.0%	6.5
2008	133	67	243	196	129	109	1	3	50.0%	4.6
2009	408	209	572	319	196	77	27	7	38.5%	5.6
2010	267	114	541	139	87	46	-17	-1	57.1%	6.5
2011	863	74	1,232	118	315	58	-28	-4	60.7%	7.7
2012	255	103	359	68	61	-61	18	-1	55.9%	8.1
2013	283	84	424	79	-60	-40	-16	-13	69.7%	6.8
2014	246	75	350	74	-22	-43	-12	-18	82.6%	7.2
2015	480	102	1,491	91	-62	-67	-46	-20	81.3%	7.2
2016	111	70	237	59	43	-13	-19	-11	72.2%	8.3
2017	155	129	278	105	-23	-64	-40	-10	74.1%	9.4
2018	338	150	810	172	83	-86	-37	-24	81.6%	6.7
2019	435	101	699	125	-467	-65	-133	-23	87.5%	9.3
Total	304	82	527	104	91	23	-14	-6	65.5%	6.8

The characteristics of the firms that make their IPO also seem to be changing slightly: in recent years the median issuer (when we look at each variable) has negative common shareholders equity, negative net income and is older than in the early millennium years.

Our brief analysis allows us to interpret the going public decision as Ritter and Welch (2002). In fact, our evidence suggests that tech firms do an IPO in response to favourable market conditions, namely when other companies in the same industry did their IPO in a recent period and had high first day returns, but only conduct an IPO when are at a certain stage in their life cycle.

5. Underpricing

Underpricing is a recurring phenomenon, with a vast literature that tries to explain it. The topic became even more important during the internet bubble, where huge levels of underpricing were reached, with several IPOs doubling in value on the first day. Our results, while not showing levels as high as the bubble period, show that underpricing exists for our sample of technology IPOs in the period after the bubble.

In this section we present our evidence related to this topic, and we try to relate underpricing to certain variables, either through simple analysis or by conducting regressions.

Our ultimate goal in this section is to answer one of our research questions: Which are the financial and non-financial underpricing value drivers of high-tech companies in the period 2001-2019?

5.1. Evidence

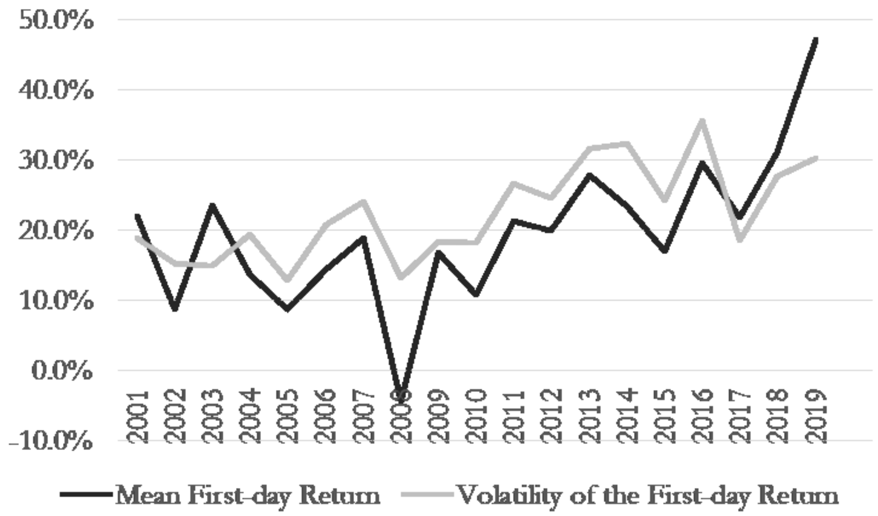
The mean underpricing of our sample for the total period under review is 19.2% and the standard deviation of the initial returns in all the period is 25%. However, these values were even higher in certain years (when we analyze the IPOs by year of issuance). For example, the mean underpricing of the companies that made their IPO in 2016 is 29.6% and the standard deviation is 35.7%. Figure 1 presents the mean and the standard deviation of the initial returns of our sample of IPOs for year of issuance.

On average underpricing is higher than the levels reported by Ibbotson (1975) for IPOs conducted in the 1960s (average underpricing of 11.4%), higher than the levels reported by Loughran and Ritter (2001) for IPOs conducted in the 1980s (average underpricing of 7%), in the 1990-1998 (average underpricing of 15%) and during 2001-2003 (average underpricing of 12%). However, the average underpricing of our sample of technology IPOs is far from reaching the levels reported during the dot-com bubble (Loughran and Ritter (2001) reached an average underpricing of 65% during 1999-2000).

In a sample of 603 IPOs, 6 had a first day return greater than 100%, that is to say they doubled their value on the first day; 64 companies had a first day return of over 50%. Underpricing is a recurring phenomenon: in the total of the twenty years under review, it did occur in all years but 2008. In fact, 461 of our 603 IPOs closed the first day of trading with a value greater than offer price.

Figure 1 – Mean Underpricing and standard deviation of the initial returns for the period 2001-2019

The mean first day return (also called mean underpricing) is the equally weighted average first day return of the 603 IPOs in our sample. The first day return is calculated for each IPO as the difference between the first day closing price and the offer price divided by the offer price. Information related to the offer price and first day closing price is from IPOScoop.com research site.



Our standard deviation of the initial returns of 25% is also lower than the standard deviation calculated by other authors. As mentioned in our Literature Review, Lowry et al. (2010) in addition to underpricing, find that there is volatility in initial returns, with a standard deviation of the initial returns during 1965-2005 of 55%, and also found that this volatility fluctuates greatly over time, so these authors believe that these values highlight the difficulty that underwriters have in valuing IPOs.

5.2. Results

5.2.1. Univariate analyses

We have net income information for the last fiscal year prior to the IPO for 563 of our companies. Of these, 369 have negative or zero net income (65.5%) and only 194 have positive net income (34.5%). Our percentage of IPO firms with negative or zero net income is well above that reported by Aggarwal et al. (2009) for the period 1986-1990 (20%) but below the percentage reported by the same authors for 1999 and 2000 (80% and 85%, respectively).

The mean underpricing if net income is negative or null is 20.8% and the mean underpricing if net income is positive is 17.2%. Table 3 shows that, according to Aggarwal et al. (2009), companies in the sample with higher net income values exhibit lower levels of underpricing, and, conversely, IPO firms with more negative earnings show higher underpricing values.

Table 3 – Underpricing analysis by different net income levels of IPO firms

This table presents the relation between underpricing and the net income in the last fiscal year before the IPO. The first day return is calculated for each IPO as the difference between the first day closing price and the offer price divided by the offer price. The mean first day return (also called mean underpricing) is the equally weighted average first day return of the IPOs that are being considered for each level of net income. Information related to the offer price and first day closing price is from IPOScoop.com research site. Data about net income is available for 563 companies, and this information is from *Datastream* database.

	Net Income ≤ -50M	-50M <Net Income ≤0	0 <Net Income ≤50M	50M <Net Income ≤100M	100M <Net Income ≤250M	Net Income >250M
Number of IPOs	65	304	167	14	10	3
Mean Underpricing	21.1%	20.7%	18.0%	11.1%	17.0%	2.1%

Table 4 shows that underpricing seems to increase as the average underpricing of the companies that conducted their IPO over the last 6 months increases.

Table 4 – Underpricing analysis for different levels of lagged underpricing in the last 6 months

This table presents the relation between underpricing and the lagged underpricing in the last 6 months. The first day return is calculated for each IPO as the difference between the first day closing price and the offer price divided by the offer price. The mean first day return (also called mean underpricing) is the equally weighted average first day return of the IPOs that are being considered for each level of lagged underpricing. The lagged underpricing is calculated in the following manner: for each IPO we calculate the average underpricing of the other firms that conducted their IPO in the last 6 months. Data is from IPOScoop.com research site. Our sample comprises 603 high-tech IPOs, but we were only able to calculate the lagged underpricing to 601.

	Lagged Underpricing 6 months ≤0%	0% < Lagged Underpricing 6 months ≤10%	10% < Lagged Underpricing 6 months ≤20%	20% < Lagged Underpricing 6 months ≤30%	Lagged Underpricing 6 months >30%
Number of IPOs	1	75	269	181	75
Mean Underpricing	15.6%	11.9%	18.4%	20.3%	26.8%

Table 5 presents the relationship between the size of the offer and the underpricing, and seems to show that smaller IPOs (those with an offer size of $50 million or less) exhibit lower levels of underpricing.

Table 6 show that the companies with the lowest levels of underpricing are the newest (four or less than four years at the time of the IPO). However, the relationship between age at the time of IPO and underpricing does not appear to be linear.

Table 5 – Underpricing analysis by different levels of offer size of IPOs

This table presents the relation between underpricing and the offer size. The first day return is calculated for each IPO as the difference between the first day closing price and the offer price divided by the offer price. The mean first day return (also called mean underpricing) is the equally weighted average first day return of the IPOs that are being considered for each level of offer size. The offer size of each IPO is equal to the offer price times the number of shares issued. Information related to the offer price and first day closing price is from IPOScoop.com research site and the number of shares issued is from the Nasdaq website. Our sample comprises 603 high-tech IPOs, but we only have data to calculate the offer size to 601 IPOs.

	Offer size ≤ 50M	50M < Offer size ≤ 100M	100M < Offer size ≤ 150M	Offer size > 150M
Number of IPOs	116	214	110	161
Mean Underpricing	8.7%	18.2%	24.7%	24.3%

Table 6 – Underpricing analysis by age of firms at the time of the IPO

This table presents the relation between underpricing and the age of firms at the IPO date. The first day return is calculated for each IPO as the difference between the first day closing price and the offer price divided by the offer price. The mean first day return (also called mean underpricing) is the equally weighted average first day return of the IPOs that are being considered for each level of age. Age is IPO date minus date of incorporation. The information related to IPO date, offer price and first day closing price is from IPOScoop.com research site and the data regarding the date of incorporation is from *Datastream* database. We have information about age for 465 of our 603 companies.

	Age ≤ 4 years	4 < Age ≤ 6 years	6 < Age ≤ 8 years	8 < Age ≤ 10 years	Age > 10 years
Number of IPOs	118	67	102	67	110
Mean Underpricing	14.3%	20.3%	16.7%	21.6%	19.0%

5.2.2. Regressions Results

Table 7 presents regressions with some explanatory power of underpricing. The $Lagged_i$, $Volatility_i$, SEO_i, $\ln(1+age)_i$ and $\ln(size)_i$ variables are statistically significant in all regressions where they are included.

Our results support the work of Bradley and Jordan (2002), which evidence a positive and strong relationship between underpricing and lagged underpricing, and the work of Welch (1989), who shows a relationship between underpricing and the desire to obtain a higher price at a seasoned public offering. In fact, the $Lagged_i$ and SEO_i variables are statistically significant in the three regressions for all significance levels and the relationship between these variables and underpricing is positive.

Table 7 – Results of our Regressions

The dependent variable in these regressions is $Underpricing_i$, the first day return for each IPO i, calculated for each one as the difference between the first day closing price and the offer price divided by the offer price. The independent variables are: $R\&D(-1)_i$, the expense on Research and Development incurred by the IPO firm i in the last fiscal year before the IPO; $R\&D(-2)_i$, the expense on Research and Development incurred by the IPO firm i in the penultimate fiscal year before the IPO; $Intangible(-1)_i$, the total intangible assets in the last fiscal year before the IPO; $Lagged_i$ is the lagged underpricing of the last last 6 months for each IPO i, it means, for each IPO we calculate the average underpricing of the other firms that conducted their IPO in the last 6 months; $Volatility_i$, is used as a proxy of uncertainty regarding each IPO i, is calculated by the difference between the higher and the lower price in the first day of trading divided by the mean of these two prices; SEO_i, is the weight of the total size of Secondary Public Offerings held within 3 years after the IPO compared to the amount of the initial offer size; $NetIncome_i$, is the Net Income in the last fiscal year before the IPO; $\ln(1+age)_i$, represents the natural logarithm of the age of each firm i at the time of the IPO; and $\ln(Size)_i$, the natural logarithm of the offer size for each IPO i. The information related to IPO date, offer price and first day closing price is from IPOScoop.com research site; the data regarding the date of incorporation, the higher and the lower price in the first day of trading and the accounting data is from *Datastream* database; data regarding the size of the offers and of the secondary equity offers is from Nasdaq website. Our sample comprises 603 IPOs, however the number of observations in each regression is lower due to the lack of information in at least one variable. The regressions presented were performed using Robust Least Squares, given the existence of heteroscedasticity. Z-statistics are in parentheses. Statistical significance is denoted by * at 0.10, ** at 0.05 and *** at 0.01.

	Regression 1 (all variables)	Regression 2	Regression 3
α	-1.883***	-1.552***	-0.059*
	(-7.48)	(-7.60)	(-1.92)
$R\&D(-1)_i$	1.33E-07		
	(0.24)		
$R\&D(-2)_i$	-2.67E-07		
	(-0.40)		
$Intangible(-1)_i$	-3.14E-08**	-1.94E-08**	-5.08E-09
	(-2.02)	(-2.39)	(-0.62)
$Lagged_i$	0.387***	0.407***	0.373***
	(2.68)	(3.06)	(2.97)
$Volatility_i$	1.103***	1.020***	1.062***
	(8.24)	(8.23)	(8.97)
SEO_i	0.025**	0.025**	0.024***
	(2.05)	(2.42)	(3.27)
$NetIncome_i$	2.91E-07**	1.64E-07	-3.22E-08
	(2.51)	(1.52)	(-0.34)
$\ln(1+age)_i$	0.046***	0.048***	
	(2.96)	(3.57)	
$\ln(size)_i$	0.095***	0.077***	
	(7.11)	(7.16)	
R^2 adjusted	15.7%	15.5%	11.8%
Adjust Rw-squared	35.4%	32.9%	24.4%
N	333	369	463

5.3. Summary

Our evidence shows that underpricing is a recurrent phenomenon, occurring for 18 of the 19 years under review (just not for 2008 when only 4 companies in our sample went public). The mean underperformance of our sample of IPOs is 19.2%, higher than the levels shown by other authors for almost all periods, except for the internet bubble period, where incredibly high underpricing levels were reached.

Our simplest analyses seem to show that IPO firms in our sample with more negative earnings show higher underpricing values, result that is in agreement with the authors who believe that negative earnings are a proxy for growth opportunities for internet companies.

Univariate analyses also evidence that the newest companies at the time of the IPO, as well as those with the smallest offer size, exhibit lower levels of underpricing. This evidence is corroborated by regressions, which show that there is a positive and statistically significant relationship between the natural logarithms of these variables and the underpricing.

Our results evidence that underpricing seems to increase as the average underpricing of the companies that conducted their IPO over the last 6 months increases, showing that some publicly information at the time of the IPO can be important to predict the levels of underpricing. In fact, in the regression we conducted, the lagged underpricing variable is statistically significant for all of the more commonly used significance levels.

The volatility variable calculated as the difference between the high price of the stock in the first day of trading minus the low price of the stock in the same day divided by the average of these two prices, is statistically significant at all levels, evidencing that the uncertainty regarding the valuation of some firms, may be one of the reasons of the underpricing.

Finally, we support the evidence of authors, such as Welch (1989) that believe that underpricing is a way to obtain higher prices in secondary equity offerings.

Although our results provide important insights into the existence and explanation of underpricing phenomenon, we believe that variables related to allocation of the shares at the time of IPO, which we unfortunately cannot test due to the lack of information available to us, is a field most likely to explain underpricing and should be a field to study in future investigations, not only for the technology companies that are the basis of our study, as well as for all IPOs in general.

6. Long-run Performance

One of our research questions is: what is the long-run performance of high-tech IPOs compared to other high-tech companies? And compared to all companies?

As mentioned previously, the long-term performance of IPOs is one of the most controversial IPO related topics. Although there are several authors, such as Ritter (1991), who evidence a strong long-run underperformance of IPOs, which suggests that investors may be too optimistic when analyse the prospects of the firms that decide to go public, there are other authors who do not believe in such a phenomenon, justifying, for example, that the results depend considerably on the methodology used, as is the case of Gompers and Lerner (2003).

To make sure that our results are as robust as possible, we conduct a series of analyses and tests using several different methodologies to analyse the performance of our sample IPOs within 3 years of the IPO.

6.1. Results

6.1.1. Event Time Results - Full Sample Results

Over three years, our sample of 603 IPOs earn 26.2% on average. A simple look at Table 8 allows us to realize that when we compare the return of all IPOs in our sample during the first three years of trading with the return of different benchmarks over the same period, our IPO portfolio appears to have a better performance than the S&P 500 Composite and the NYSE Composite (wealth relatives of 1.09 and 1.13, respectively), a performance very similar to that of Nasdaq Composite (wealth relative of 1.01) and shows a slightly worse performance than the Nasdaq 100 Tech Sector (wealth relative of 0.97).

6.1.2. Event Time Results - Yearly Cohort Results

According to Ritter (1991) the underperformance of the IPOs three years after the IPO date is not as general a phenomenon as the high first day returns. The author find a negative relation between the number of firms conducting their IPO in each year and the aftermarket performance.

When looking at the performance of our sample by year of issuance (Table 9), it is not easy to establish relationships with the volume of IPOs each year. For instance, 2012 and 2013, with a similar number of IPOs, have very different performances: 2012 is a year when wealth relatives are all above 1 regardless of the benchmark used, while 2013 is the worst year ever when we use as benchmark the Nasdaq Composite. The number of years with wealth relative above one is similar to the number of years with wealth relative below one when we used Nasdaq Composite as a benchmark, but there are more years when our sample of IPOs outperform the benchmark when the benchmark used is the S&P 500 Composite or the NYSE Composite.

Table 8 - Three Year Post-IPO Equal Weighted Buy and Hold Returns and Wealth Relatives versus Various Benchmarks

The 3-year buy and hold returns are the total return from a buy and hold strategy where a stock is purchased at the end of the first trading day after the IPO and is held for three years (or until the delisting date or until June 2019 if any of these moments occur before the IPO's third anniversary). The 3-year buy and hold return of each IPO is calculated as explained in section 3.1.2.1. These returns are compared with alternative benchmarks. The return of each benchmark was calculated for several different periods, corresponding to the same period for which the returns of each IPO are calculated. The wealth relative is the ratio of one plus the average IPO 3-year holding period return divided by one plus the average 3-year holding period return of the respective benchmark. Data is from *Datastream* database and allows us to calculate the 3-year buy and hold return of 568 IPOs from the 603 companies in the sample. The NASDAQ-100 Technology Sector Index began on February 22, 2006, so it can only be compared with the 419 IPOs that took place after that date and for which we have data.

Benchmarks	Number of IPOs	IPO Return	Benchmark Return	Wealth Relative
Nasdaq Composite	568	26.2%	24.9%	1.01
S&P 500 Composite	568	26.2%	15.8%	1.09
NYSE Composite	568	26.2%	11.2%	1.13
Nasdaq 100 Tech Sector	419	31.2%	35.3%	0.97

Thus, our evidence leads us to agree with Ritter (1991), who states that the underperformance phenomenon is not as general as the underpricing phenomenon, but we cannot establish a relationship between annual volume and performance, such as said author.

Additionally, it should be noted that analyse the mean values or the median values leads us to draw different conclusions. When analysing the average values our portfolio of IPOs seems to perform similar to benchmarks, when analysing the median values our portfolio of IPOs seems to show severe underperformance.

Table 9 - Three Year Post-IPO Equal Weighted Buy and Hold Returns and Wealth Relatives by Year of Issuance

The 3-year buy and hold returns are the total return from a buy and hold strategy where a stock is purchased at the end of the first trading day after the IPO and is held for three years (or until the delisting date or until June 2019 if any of these moments occur before the IPO's third anniversary). The 3-year buy and hold return of each IPO is calculated as explained in section 3.1.2.1. These returns are compared with alternative benchmarks. The return of each benchmark was calculated for several different periods, corresponding to the same period for which the returns of each IPO are calculated. The wealth relative is the ratio of one plus the average IPO 3-year holding period return by one plus the average 3-year holding period return of the respective benchmark. The number of IPOs to be compared with the Nasdaq 100 Tech Sector in 2006 is only 39, as this index only started on February 22, 2006. In total, this index is compared to the 419 IPOs that took place after that date and for which we have data. The number of IPOs to be compared with the other benchmarks is 568, as it is the number of firms for which we have data to calculate the returns. Data is from *Datastream* database.

		Average 3-year holding period total return					Wealth Relatives			
Year of Issuance	Number of IPOs	IPOs	Nasdaq Composite	S&P 500 Composite	NYSE Composite	Nasdaq 100 Tech Sector	Nasdaq Composite	S&P 500 Composite	NYSE Composite	Nasdaq 100 Tech Sector
2001	23	-10.4%	0.6%	-3.7%	5.1%		0.89	0.93	0.85	
2002	17	30.7%	25.7%	13.1%	21.9%		1.04	1.16	1.07	
2003	12	-1.2%	25.3%	30.2%	46.6%		0.79	0.76	0.67	
2004	53	34.9%	33.1%	32.8%	48.8%		1.01	1.02	0.91	
2005	39	-2.8%	-1.5%	-3.4%	4.2%		0.99	1.01	0.93	
2006	43	-22.7%	-15.7%	-25.6%	-24.7%	-7.6%	0.92	1.04	1.03	0.82
2007	66	-15.3%	-8.8%	-22.8%	-25.3%	3.1%	0.93	1.10	1.13	0.82
2008	4	19.4%	17.0%	-0.5%	-5.8%	32.3%	1.02	1.20	1.27	0.90
2009	12	43.1%	53.0%	40.4%	24.7%	48.8%	0.94	1.02	1.15	0.96
2010	34	31.8%	47.6%	42.2%	28.8%	36.0%	0.89	0.93	1.02	0.97
2011	29	23.4%	57.9%	47.5%	31.3%	48.1%	0.78	0.84	0.94	0.83
2012	33	80.7%	65.3%	49.2%	34.1%	63.8%	1.09	1.21	1.35	1.10
2013	34	-4.2%	39.7%	26.4%	9.3%	52.4%	0.69	0.76	0.88	0.63
2014	47	40.4%	43.0%	27.5%	11.5%	66.1%	0.98	1.10	1.26	0.85
2015	31	84.2%	48.7%	32.3%	17.6%	77.4%	1.24	1.39	1.57	1.04
2016	20	134.5%	51.7%	34.1%	19.9%	70.5%	1.55	1.75	1.96	1.38
2017	28	84.0%	23.4%	16.5%	6.9%	21.7%	1.49	1.58	1.72	1.51
2018	35	6.7%	5.2%	5.0%	0.7%	5.1%	1.01	1.02	1.06	1.01
2019	8	24.3%	1.9%	2.3%	1.1%	-2.5%	1.22	1.22	1.23	1.28
	568									
Mean		26.2%	24.9%	15.8%	11.2%	35.3%	1.01	1.09	1.13	0.93
Median		0.4%	28.0%	24.0%	12.0%	37.0%	0.78	0.81	0.90	0.73

6.1.3. Event Time Results - Performance categorized by Offer Size, First day Returns and Age

In order to further investigate the performance of our sample IPOs, we have divided our IPOs into different categories. For the sake of simplicity, in this analysis we use only the Nasdaq Composite as a benchmark, an index that has several technology firms as constituents and the Nasdaq-100 Technology Sector Index.

Table 10 shows that IPOs that perform poorly in absolute terms are the IPOs with the lowest offer size values, with only 7.1% of average 3-year buy and hold return. Consequently, it is also these IPOs that perform poorly in relative terms, showing underperformance both when compared to the Nasdaq Composite (wealth relative of 0.88) and when compared to the Nasdaq 100 Tech Sector (wealth relative of 0.82). In line with our results presented in Table 10, Brav and Gompers (1997) when analysing venture-backed and non-venture-backed IPOs concluded that the underperformance recorded in their non-venture-backed sample is primarily driven by issuers with market capitalization less than $50 million, it means, the smaller ones.

Table 10 - Three Year Post-IPO Equal Weighted Buy and Hold Returns and Wealth Relatives categorized by Gross Proceeds

The 3-year buy and hold returns are the total return from a buy and hold strategy where a stock is purchased at the end of the first trading day after the IPO and is held for three years (or until the delisting date or until June 2019 if any of these moments occur before the IPO's third anniversary). The 3-year buy and hold return of each IPO is calculated as explained in section 3.1.2.1. These returns are compared with alternative benchmarks. The return of each benchmark was calculated for several different periods, corresponding to the same period for which the returns of each IPO are calculated. The wealth relative is the ratio of one plus the average IPO 3-year holding period return by one plus the average 3-year holding period return of the respective benchmark. The gross proceeds of each IPO are equal to the offer price times the number of shares issued. Information related to the offer price is from IPOScoop.com research site and the number of shares issued is from the Nasdaq website. Data available to calculate the returns is from *Datastream* database and allows us to calculate the return of 568 IPOs from our sample of 603 IPOs. Crossing this information with the gross proceeds data available to 601 companies, we get a number of observations of 566 when we use Nasdaq Composite as a benchmark. This number is lower (419) when compared to the Nasdaq 100 Tech Sector, as this index only started on February 22, 2006.

Gross Proceeds, $	Number of IPOs	Average 3-year holding period total return		Wealth Relative	Number of IPOs	Average 3-year holding period total return		Wealth Relative
		IPOs	Nasdaq Composite			IPOs	Nasdaq 100 Tech Sector	
6,800,000 - 49,999,999	106	7.1%	21.8%	0.88	61	8.6%	31.9%	0.82
50,000,000 - 99,999,999	207	29.6%	26.7%	1.02	151	30.5%	36.7%	0.95
100,000,000 - 249,999,999	172	32.9%	24.2%	1.07	137	41.8%	35.1%	1.05
250,000,000 - 16,006,877,370	81	29.0%	25.7%	1.03	70	31.6%	35.4%	0.97
	566				419			
Mean		26.3%	24.9%	1.01		31.2%	35.3%	0.97
Median		0.4%	28.4%	0.78		0.5%	36.8%	0.73

Table 11 shows that the IPOs that perform worst, both in absolute and relative terms, are those whose first day initial return is negative or zero. In fact, these IPOs show severe underperformance when compared to both benchmarks. Our results differ from those of Ritter (1991); our evidence, based on Table 11, does not support the overreaction hypothesis[4], whereas Ritter's (1991) evidence supports, at least in part, that hypothesis.

Analysing by age of the firm at the time of going public (Table 12) we can conclude that, although the relationship between age and performance is not linear, companies over 6 years old perform better than companies under 6 years old. In fact, on average, companies

[4] DeBondt and Thaler (1985, 1987) evidence that the relation between initial returns and subsequent abnormal returns is negative, at least for stocks with lower market capitalization, using holding periods of one year or more. These findings are interpreted as evidence of market overreaction (Ritter, 1991).

under the age of 6 at the time of the IPO are those that underperform (wealth relative of less than one, for both benchmarks).

Table 11 - Three Year Post-IPO Equal Weighted Buy and Hold Returns and Wealth Relatives categorized by First day Return

The 3-year buy and hold returns are the total return from a buy and hold strategy where a stock is purchased at the end of the first trading day after the IPO and is held for three years (or until the delisting date or until June 2019 if any of these moments occur before the IPO's third anniversary). The 3-year buy and hold return of each IPO is calculated as explained in section 3.1.2.1. These returns are compared with alternative benchmarks. The return of each benchmark was calculated for several different periods, corresponding to the same period for which the returns of each IPO are calculated. The wealth relative is the ratio of one plus the average IPO 3-year holding period return by one plus the average 3-year holding period return of the respective benchmark. The first day return is calculated for each IPO as the difference between the first day closing price and the offer price divided by the offer price. Information related to the offer price and first day closing price is from IPOScoop.com research site and the data to calculate the 3-year buy and hold returns is from *Datastream* database. We have data that allows us to calculate the first day return of all the 603 IPOs in our sample, but due to the lack of data to calculate returns, the number of observations is 568 when we use Nasdaq Composite as a benchmark. This number is lower (419) when compared to the Nasdaq 100 Tech Sector, as this index only started on February 22, 2006.

Initial Return, %	Number of IPOs	Average 3-year holding period total return		Wealth Relative	Number of IPOs	Average 3-year holding period total return		Wealth Relative
		IPOs	Nasdaq Composite			IPOs	Nasdaq 100 Tech Sector	
Initial Return ≤0	124	1.7%	26.5%	0.80	91	-2.9%	39.0%	0.70
0< Initial Return ≤10	121	31.7%	22.8%	1.07	74	37.1%	29.6%	1.06
10< Initial Return ≤20	102	25.0%	19.0%	1.05	71	32.1%	31.8%	1.00
20< Initial Return ≤30	72	38.9%	32.9%	1.05	60	43.1%	40.8%	1.02
Initial Return >30	149	36.8%	25.3%	1.09	123	46.3%	35.1%	1.08
	568				419			
Mean		26.2%	24.9%	1.01		31.2%	35.3%	0.97
Median		0.4%	28.3%	0.78		0.5%	36.8%	0.73

Table 12 – Three Year Post-IPO Equal Weighted Buy and Hold Returns and Wealth Relatives categorized by Age

The 3-year buy and hold returns are the total return from a buy and hold strategy where a stock is purchased at the end of the first trading day after the IPO and is held for three years (or until the delisting date or until June 2019 if any of these moments occur before the IPO's third anniversary). The 3-year buy and hold return of each IPO is calculated as explained in section 3.1.2.1. These returns are compared with alternative benchmarks. The return of each benchmark was calculated for several different periods, corresponding to the same period for which the returns of each IPO are calculated. The wealth relative is the ratio of one plus the average IPO 3-year holding period return by one plus the average 3-year holding period return of the respective benchmark. Age is IPO date minus date of incorporation. The information related to IPO date is from IPOScoop.com research site and the data to calculate the 3-year buy and hold returns and about the date of incorporation is from *Datastream* database. We have data to calculate the age at the time of IPO for 464 companies in our sample, as we only have information about the company incorporation date for this number of companies. Crossing this data with the calculation of the return, for which we have data for 568 companies, we get a number of observations of 450 when we use Nasdaq Composite as a benchmark and of 326 when the Nasdaq 100 Tech Sector is used, as this index only started on February 22, 2006.

Age, years	Number of IPOs	Average 3-year holding		Wealth Relative	Number of IPOs	Average 3-year holding		Wealth Relative
		IPOs	Nasdaq Composite			IPOs	Nasdaq 100 Tech Sector	
Age ≤4	116	19.3%	20.6%	0.99	86	17.1%	30.8%	0.90
4< Age ≤6	64	-0.5%	17.0%	0.85	33	-6.2%	19.1%	0.79
6< Age ≤8	95	28.1%	19.0%	1.08	72	34.4%	29.0%	1.04
8< Age ≤10	66	60.2%	25.9%	1.27	49	78.8%	37.1%	1.30
Age >10	109	33.3%	30.3%	1.02	86	35.5%	39.4%	0.97
	450				326			
Mean		27.6%	22.9%	1.04		32.7%	32.4%	1.00
Median		-2.0%	24.3%	0.79		-4.5%	31.2%	0.73

Although we are looking at the technology industry as a whole, the data in Table 19 of Appendix B allow us to show that performance over the three years following the IPO is not the same for companies in different subsectors. The software subsector comprises a large number of IPOs and these IPOs are clearly the ones that perform best in three years (45.6%). The navigation equipment, communications equipment and communications services companies show severe underperformance (with wealth relatives of 0.47, 0.67 and 0.68, respectively), showing very negative returns (-38.6%, -17.2% and -15.5%, respectively).

The companies in our sample are not the same, and the characteristics that set them apart seem to explain, at least in part, their performance. Our results seem to show that underperformance is a phenomenon that occurs in the technology industry: for smaller IPOs, with gross proceeds under $50 million; for those that had a negative return on the first day of trading; for younger firms, under the age of six at the time of the IPO; and for some specific subsectors that are part of this industry that we are looking at.

6.1.4. Calendar Time Results

The calendar time returns are compared to the four benchmarks in Table 13. As in the work of Brav and Gompers (1997), the number of years with underperformance has decreased when we look at calendar time results. In fact, our results show underperformance only in six years compared to Nasdaq Composite, five years compared to S&P 500 Composite or NYSE Composite and four years compared to Nasdaq 100 Tech Sector. Only the years 2002, 2008, 2011, 2014, 2015 and 2016 show some underperformance.

Evidence of underperformance decreases dramatically when we look at calendar time results, supporting the opinion of Brav and Gompers (1997) when they claim that view each IPO as an independent event may overstate the significance of estimated underperformance.

6.1.5. Fama-French (1993) Three Factor Model

Table 14 presents our three factor time series regression results using all sample. The regression is for February 2001 through June 2019 for a total of 221 observations (t-statistics are in parentheses). The intercept is -0.103, which is -10.3 basis points per month, resulting in about -1.24% per year, with a t-statistic of -11.4. This result, while evidencing that there is underperformance for our sample of IPOs, shows a lower level of underperformance compared with other authors. In fact, Ritter and Welch (2002) report an underperformance of -21 basis points per month[5] (about 2 times higher than our result).

Table 13 – Calendar Time IPO Performance

The monthly returns on portfolios constituted by an equal amount of the IPO firms of the sample that went public within the previous three years was calculated. In other words, the return for each month is equal to the average return of the sample stocks that were not listed for more than 3 years at the end of that month. The annual return is calculated by compounding monthly returns on the IPO portfolios from January to December of each year. The only exceptions are 2001, where the annual return is calculated by compounding monthly returns from February to December, since we have no IPO in our sample in January 2001, and 2019, where we only have data until June. These calendar time returns are compared with four benchmarks. The annual benchmark returns are also calculated by compounding monthly returns for the same period. Data is from *Datastream* database. The number of IPOs used to calculate the values shown in the table is 561, due to lack of information.

	Average 3-year holding period total return					Wealth Relatives			
Year	IPOs	Nasdaq Composite	S&P 500 Composite	NYSE Composite	Nasdaq 100 Tech Sector	Nasdaq Composite	S&P 500 Composite	NYSE Composite	Nasdaq 100 Tech Sector
2001	30.5%	-29.7%	-16.0%	-11.1%		1.86	1.55	1.47	
2002	-44.8%	-31.5%	-23.4%	-19.8%		0.81	0.72	0.69	
2003	122.7%	50.0%	26.4%	28.8%		1.48	1.76	1.73	
2004	59.3%	8.6%	9.0%	12.6%		1.47	1.46	1.41	
2005	17.3%	1.4%	3.0%	7.0%		1.16	1.14	1.10	
2006	34.0%	9.5%	13.6%	17.9%	6.2%	1.22	1.18	1.14	1.26
2007	23.7%	9.8%	3.5%	6.6%	7.8%	1.13	1.19	1.16	1.15
2008	-54.3%	-40.5%	-38.5%	-40.9%	-45.2%	0.77	0.74	0.77	0.83
2009	99.9%	43.9%	23.5%	24.8%	79.6%	1.39	1.62	1.60	1.11
2010	80.6%	16.9%	12.8%	10.8%	21.6%	1.54	1.60	1.63	1.49
2011	-21.8%	-1.8%	0.0%	-6.1%	-6.0%	0.80	0.78	0.83	0.83
2012	26.3%	15.9%	13.4%	12.9%	7.2%	1.09	1.11	1.12	1.18
2013	111.4%	38.3%	29.6%	23.2%	37.0%	1.53	1.63	1.72	1.54
2014	5.4%	13.4%	11.4%	4.2%	23.9%	0.93	0.95	1.01	0.85
2015	-0.9%	5.7%	-0.7%	-6.4%	-2.3%	0.94	1.00	1.06	1.01
2016	1.8%	7.5%	9.5%	9.0%	24.1%	0.95	0.93	0.93	0.82
2017	44.6%	28.2%	19.4%	15.8%	36.7%	1.13	1.21	1.25	1.06
2018	8.9%	-3.9%	-6.2%	-11.2%	-5.5%	1.13	1.16	1.23	1.15
2019	47.8%	20.7%	17.3%	14.7%	25.8%	1.23	1.26	1.29	1.18
Mean	31.2%	8.6%	5.7%	4.9%	15.1%	1.21	1.24	1.25	1.14
Median	26.3%	9.5%	9.5%	9.0%	14.7%	1.15	1.15	1.16	1.10

Ritter and Welch (2002) believe that we should be careful comparing papers which attribute the disappearance or weakening of the IPO underperformance to novel measurement techniques, justifying that some of the conclusions may be due to the sample period.

[5] Using a sample period from January 1973 to September 2001, for IPOs of all sectors.

Thus, we believe it is important to analyse subperiods (Panel A of table 15). Like Ritter and Welch (2002) we also analyse the sensitivity of intercepts when we expand the number of factors (Panel B of Table 15).

Of the eight subperiods we analysed, only one (January 2009-December 2014) has a positive intercept, however it is not statistically significant. All other subperiods have a negative intercept, all of which are statistically significant.

Table 14 – Fama-French (1993) Three Factor Regression on IPO Portfolios for the whole sample

This table presents our three factor model of Fama and French (1993) results. The model is $R_{pt} - R_{ft} = \alpha + \beta_t (R_{mt}-R_{ft}) + s_t SMB_t + v_t HML_t + e_{pt}$. The dependent variable in this model is the monthly return on portfolios constituted by an equal amount of all IPO firms of our sample that went public within the previous three years, as explained before. R_{pt}-R_{ft} is the excess return over the risk-free rate on a portfolio in period t. The three factors of Fama and French (1993) model are: R_{mt}-R_{ft}, which is the excess return on the value weighted market portfolio in month t; SMB_t, small minus big, the difference between the return on a portfolio of small stocks and the return on a portfolio of big stocks in period t, and HML_t, high minus low, the return on a zero investment portfolio calculated as the difference of return on a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks in period t. The risk-free rate in month t (R_{ft}) is the one-month Treasury bill rate and the three factors of Fama and French (1993) model were taken from the Data Library of Kenneth R. French. Data to calculate the portfolio returns is from *Datastream* database. The number of IPOs used to calculate the portfolio returns is 561, due to lack of information. The intercept from regression is used as an indicator of risk-adjusted performance; it is a measure of abnormal performance. The regression is for February 2001 through June 2019, for a total of 221 observations (t-statistics are in parentheses). Statistical significance is denoted by * at 0.10, ** at 0.05 and *** at 0.01.

	α	β_t	s_t	v_t	R^2 adjusted
February 2001 - June 2019	-0.103***	0.018***	0.013***	-0.011***	32.9%
	(-11.4)	(8.11)	(3.34)	(-3.35)	

The subperiods that span the years of the first decade of the millennium are those in which underperformance levels appear to be highest. From February 2001 to December 2008, for example, an intercept of -0.203 is -20.3 basis points per month, about -2.463% per year.

Row 9 reports the results of a simple one factor regression and row 10 reports the results of a regression that also includes a lagged market return. The beta is statistically significant, and the lagged beta is statistically significant at a significance level of 0.05. The summed beta is 0.023, indicating that our IPOs have a low level of systematic risk, unlike the results of Ritter and Welch (2002) who get a summed beta of 1.73.

We, like Brav and Gompers (1997), also estimate equal weighted regressions within each of the three size groups that we created, as explained in the methodology. The results are presented in Table 16.

As expected, the tercile with the lowest intercept is the small tercile. An intercept of -0.106 is -10.6 basis points per month, about -1.279% per year. The tercile with the least negative intercept is the large tercile. An intercept of -0.098 is -9.8 basis points per month, about -1.182% per year. All intercepts presented in Table 16 are statistically significant.

Table 15 – Fama-French (1993) Three Factor Regressions on IPO Portfolios - Sensitivity of the Intercepts to different sample periods and to expanding the number of factors

This table presents our three factor model of Fama and French (1993) results. The model in panel A is $R_{pt} - R_{ft} = \alpha + \beta_t (R_{mt}-R_{ft}) + s_t SMB_t + v_t HML_t + e_{pt}$. The dependent variable in this model is the monthly return on portfolios constituted by an equal amount of all IPO firms of our sample that went public within the previous three years, as explained before. R_{pt}-R_{ft} is the excess return over the risk-free rate on a portfolio in period t. The three factors of Fama and French (1993) model are: R_{mt}-R_{ft}, which is the excess return on the value weighted market portfolio in month t; SMB_t, small minus big, the difference between the return on a portfolio of small stocks and the return on a portfolio of big stocks in period t, and HML_t, high minus low, the return on a zero investment portfolio calculated as the difference of return on a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks in period t. In the regressions of panel B we add the lagged Fama-French factors to the model, the number of observations is 220, from March 2001 to June 2019. The risk-free rate in month t (R_{ft}) is the one-month Treasury bill rate and the three factors of Fama and French (1993) model were taken from the Data Library of Kenneth R. French. Data to calculate the portfolio returns is from *Datastream* database. The number of IPOs used to calculate the portfolio returns is 561, due to lack of information. The intercepts from regressions is used as an indicator of risk-adjusted performance; it is a measure of abnormal performance). Statistical significance is denoted by * at 0.10, ** at 0.05 and *** at 0.01 (t-statistics are in parentheses).

	α	β_t	β_{t-1}	s_t	s_{t-1}	v_t	v_{t-1}	R^2 adjusted
Panel A: Sensitivity of the Intercepts to Different Sample Periods								
(1) February 2001 - December 2002	-0.173***	0.020***		0.016**		-0.012*		73.8%
	(-7.55)	(4.76)		(2.81)		(-2.03)		
(2) February 2001 - December 2004	-0.123***	0.022***		0.016***		-0.012**		69.5%
	(-7.90)	(6.86)		(3.29)		(-2.44)		
(3) February 2001 - December 2008	-0.203***	0.013***		0.022***		-0.009*		36.3%
	(-14.31)	(4.05)		(4.16)		(-1.70)		
(4) January 2003 - December 2004	-0.071***	0.012*		0.021***		-0.005		46.4%
	(-4.09)	(2.05)		(2.85)		(-0.50)		
(5) January 2005 - December 2008	-0.284***	-0.002		0.026***		-0.002		16.0%
	(-19.03)	(-0.57)		(3.34)		(-0.35)		
(6) January 2009 - December 2014	0.007	0.013***		0.009***		-0.005*		64.0%
	(1.09)	(8.00)		(3.40)		(-1.99)		
(7) January 2009 - June 2019	-0.024***	0.012***		0.012***		-0.004		45.3%
	(-3.67)	(7.27)		(4.27)		(-1.41)		
(8) January 2015 - June 2019	-0.065***	0.010***		0.014***		-0.005		37.2%
	(-6.33)	(3.70)		(3.24)		(-1.12)		
Panel B: Sensitivity of Intercepts to expanding the number of Factors								
(9) February 2001 - June 2019	-0.102***	0.020***						27.0%
	(-10.85)	(9.07)						
(10) February 2001 - June 2019	-0.103***	0.018***	0.005**					26.8%
	(-10.97)	(8.49)	(2.25)					
(11) February 2001 - June 2019	-0.103***	0.018***		0.013***		-0.011***		32.9%
	(-11.4)	(8.11)		(3.34)		(-3.35)		
(12) February 2001 - June 2019	-0.104***	0.017***	0.005**	0.012***	0.000	-0.010***	-0.004	32.2%
	(-11.49)	7.48	2.35	3.16	0.11	(-2.92)	(-1.21)	

Table 16 – Fama-French (1993) Three Factor Regression on IPO Portfolios sorted on the basis of size

This table presents our three factor model of Fama and French (1993) results. The model is $R_{pt} - R_{ft} = \alpha + \beta_t (R_{mt}-R_{ft}) + s_t SMB_t + v_t HML_t + e_{pt}$. The dependent variable in this model is the monthly return on portfolios constituted by an equal amount of all IPO firms of our sample that went public within the previous three years, as explained before. $R_{pt}-R_{ft}$ is the excess return over the risk-free rate on a portfolio in period t. The three factors of Fama and French (1993) model are: $R_{mt}-R_{ft}$, which is the excess return on the value weighted market portfolio in month t; SMB_t, small minus big, the difference between the return on a portfolio of small stocks and the return on a portfolio of big stocks in period t, and HML_t, high minus low, the return on a zero investment portfolio calculated as the difference of return on a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks in period t. Beyond regression with the whole sample, we sorted the sample on the basis of size. Every month we divide our sample of IPOs into three size portfolios (an equal number of stocks are allocated to each tercile) based on the previous month's market capitalization using all IPOs to determine the breakpoints. In the first month of trading, as there is no market capitalization from the previous month, the offer size was used. The portfolios are rebalanced monthly and IPOs are allowed to switch portfolios every month. Portfolio returns are the equal weighted returns for IPOs within each size group. The risk-free rate in month t (R_{ft}) is the one-month Treasury bill rate and the three factors of Fama and French (1993) model were taken from the Data Library of Kenneth R. French. Data to calculate the portfolio returns is from *Datastream* database. The number of IPOs used to calculate the portfolio returns is 561 from our sample of 603, due to lack of information. The intercepts from regressions is used as an indicator of risk-adjusted performance; it is a measure of abnormal performance. The regressions are for February 2001 through June 2019, for a total of 221 observations (t-statistics are in parentheses). Statistical significance is denoted by * at 0.10, ** at 0.05 and *** at 0.01.

	α	β_t	s_t	v_t	R^2 adjusted
(1) Full Sample	-0.103***	0.018***	0.013***	-0.011***	32.9%
	(-11.4)	(8.11)	(3.34)	(-3.35)	
(2) Small Tercile	-0.106***	0.018***	0.015***	-0.012***	31.7%
	(-10.89)	(7.57)	(3.69)	(-3.32)	
(3) Medium Tercile	-0.105***	0.019***	0.011***	-0.010***	28.9%
	(-10.43)	(7.70)	(2.69)	(-2.78)	
(4) Large Tercile	-0.098***	0.016***	0.012***	-0.011***	25.4%
	(-9.68)	(6.69)	(2.85)	(-3.01)	

The change in discount is not statistically significant in any of the four regressions presented in Table 17. Additionally, the coefficients are positive, so our evidence does not match evidence from Brav and Gompers (1997) who concluded that the change in discount was negatively related to returns from the smallest group of IPOs. Thus, our evidence does not support the idea that investor sentiment might be an important source of underperformance. Even analysing subperiods, in regressions not presented here, the results do not change significantly.

6.2. Summary

When we look at the three-year period post-IPO equal weighted buy and hold returns, our sample of IPOs earn 26.2% on average and do not appear to show signs of underperformance compared to the four benchmarks we use. When we analyse the same variable by year of issuance, our evidence leads us to agree with Ritter (1991), when the author states that the underperformance phenomenon is not as general as the underpricing phenomenon. In fact, the number of years that evidence the existence of underperformance is similar to the number of years that does not evidence the existence of such a phenomenon. When we look at years using Calendar Time Results, the evidence in favour of underperformance is even smaller: only six years of our sample period seems to evidence underperformance.

Table 17 – Fama-French (1993) Three Factor Regression on IPO Portfolios including the change in the average Closed-end Fund Discount

This table presents our three factor model of Fama and French (1993) results including an index that measures the change in the average discount on closed-end funds. The model is $Rp_t - Rf_t = \alpha + \beta_t (Rm_t\text{-}Rf_t) + s_t SMB_t + v_t HML_t + \Delta Discount_t + e_{pt}$. The dependent variable in this model is the monthly return on portfolios constituted by an equal amount of all IPO firms of our sample that went public within the previous three years, as explained before. Rp_t-Rf_t is the excess return over the risk-free rate on a portfolio in period t. The three factors of Fama and French (1993) model are: Rm_t-Rf_t, which is the excess return on the value weighted market portfolio in month t; SMB_t, small minus big, the difference between the return on a portfolio of small stocks and the return on a portfolio of big stocks in period t, and HML_t, high minus low, the return on a zero investment portfolio calculated as the difference of return on a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks in period t. $\Delta Discount_t$ is calculated as explained in section 3.1.2.3., based on the work of Lee et al. (1991). Beyond regression with the whole sample, we sorted the sample on the basis of size. Every month we divide our sample of IPOs into three size portfolios (an equal number of stocks are allocated to each tercile) based on the previous month's market capitalization using all IPOs to determine the breakpoints. In the first month of trading, as there is no market capitalization from the previous month, the offer size was used. The portfolios are rebalanced monthly and IPOs are allowed to switch portfolios every month. Portfolio returns are the equal weighted returns for IPOs within each size group. The risk-free rate in month t (Rf_t) is the one-month Treasury bill rate and the three factors of Fama and French (1993) model were taken from the Data Library of Kenneth R. French. Data to calculate the portfolio returns is from *Datastream* database. The number of IPOs used to calculate the portfolio returns is 561 from our sample of 603, due to lack of information. The intercepts from regressions is used as an indicator of risk-adjusted performance; it is a measure of abnormal performance. The regressions are for February 2001 through June 2019, for a total of 221 observations (t-statistics are in parentheses). Statistical significance is denoted by * at 0.10, ** at 0.05 and *** at 0.01.

	α	β_t	s_t	v_t	ΔDiscount	R^2 adjusted
(1) Full Sample	-0.103***	0.018***	0.013***	-0.011***	0.036	32.7%
	(-11.37)	(8.10)	(3.34)	(-3.35)	(0.30)	
(2) Small Tercile	-0.106***	0.018***	0.015***	-0.012***	0.044	31.4%
	(-10.88)	(7.57)	(3.69)	(-3.35)	(0.34)	
(3) Medium Tercile	-0.105***	0.019***	0.011***	-0.010***	0.033	28.6%
	(-10.41)	(7.69)	(2.69)	(-2.78)	(0.25)	
(4) Large Tercile	-0.098***	0.016***	0.012***	-0.011***	0.030	25.0%
	(-9.66)	(6.67)	(2.85)	(-3.01)	(0.23)	

When we present our Fama and French (1993) three factor time series regression using all sample, we evidence the existence of underperformance (-10.3 basis points per month, about -1.24% per year). However, this result, while evidencing that there is underperformance for our sample of technology IPOs, shows a lower level of underperformance than other authors, such as Ritter and Welch (2002) (-21 basis points per month, about -2.55% per year). Following the works of Lee et al. (1991) and Brav and Gompers (1997) we include an index that measures the change in the average discount on closed-end funds in our three factor regressions and our evidence does not support the idea that investor sentiment might be an important source of underperformance.

Therefore, although we show that there is underperformance within three years after the IPO, for the technology companies in the U.S. market that conduct their IPOs from 2001 until April 18, 2019, our evidence of underperformance is weak compared to results of other authors, aforementioned, and we also don't find evidence that investor sentiment might be an explanation of the levels of underperformance reached.

However, although our evidence of underperformance is less strong than that of other authors, it does not mean that it does not exist for our sample. The presented results of the Fama and French (1993) model evidence the existence of underperformance. However, in our opinion, this underperformance is not a sign of overreaction on the first trading day, given that, according to Table 11, the IPOs that underperform, on average, are those that were not underpriced on the first trading day, it means, are those whose first day initial return is less than or equal to zero. Those who found underpricing on the first day, that is, whose first day close price was higher than the offer price, have wealth relatives greater than 1, either when compared to Nasdaq Composite or compared to Nasdaq 100 Tech Sector, thus showing no signs of underperformance.

Thus, our results seem to show that there is underpricing and underperformance in our sample, however there seems to be no sign of overreaction. In contrast, IPOs whose market is unreliable on day one are the worst performers over the next three years.

7. Conclusions

We use a sample of 603 high-tech IPOs, conducted between January 2001 through April 18, 2019, on U.S. exchanges, with the purpose of answer the following two research questions: which are the financial and non-financial underpricing value drivers of high-tech companies in the period 2001-2019 and what is the long-run performance of high-tech IPOs compared to other high-tech companies and compared to all companies.

We start by understanding why the companies in our sample choose to go public. In fact, the number of technology companies conducting IPOs is not equal from year to year, by contrast, which raises the debate about why companies choose to go public and why these reasons seem to be more important at certain times than they are in others. The characteristics of the firms that make their IPO also seem to be changing: in recent years, the median issuer has negative common equity and has negative net income.

In a brief analysis we realize that the companies in our sample increased their R&D expenses and CapEx in the years following the IPO, so the need to fund new projects may be one of the reasons for choosing to conduct an IPO. To grab market share may be another reason why some firms decide to do an IPO, and most of our firms conducted their IPO at a time when the average underpricing of the last 6 months was over 15%, demonstrating that they may take into account the market in choosing when to go public.

Our evidence allows us to interpret the going public decision as Ritter and Welch (2002): high-tech firms seem to do an IPO in response to favourable market conditions, but only when are at a certain stage in their life cycle.

Underpricing is a recurrent phenomenon, occurring for all years under review, excluding 2008. The average first day return of our 603 IPOs is 19.2%.

Our univariate results evidence that companies with more negative earnings show higher underpricing values; what is in agreement with the authors who believe negative earnings are a proxy for growth opportunities for internet companies. However, the variable related to net income introduced in the regressions presented in Table 7 does not seem to have great statistical significance.

Univariate results also evidence that the newest companies at the time of the IPO and those with the smallest offer size, exhibit lower levels of underpricing. This evidence is corroborated by regressions, which show that there is a positive and statistically significant relationship between the natural logarithms of these variables and the underpricing.

Underpricing, in the univariate analyses, seems to increase as the average underpricing of the companies that conducted their IPO over the last 6 months increases, showing that some publicly information at the time of the IPO can be important to predict the levels of underpricing. In fact, in the regressions we conducted, the lagged underpricing variable is statistically significant for all of the more commonly used significance levels.

The volatility variable included in the regressions presented in Table 7 is statistically significant at all levels, evidencing that the uncertainty regarding the valuation of some firms, may be another reason of the underpricing.

Finally, we support the evidence of the authors that believe that underpricing is a way to obtain higher prices in secondary equity offerings.

Although our results identify some variables as significant in explaining underpricing, we believe that variables related to allocation of shares, which we unfortunately cannot test due to lack of information, is a very important field to explain underpricing. We consider this field so important that we suggest that future studies related to this theme should increasingly consider these issues. Those who have sufficient information to study the relationship between the allocation of shares and underpricing can, in our opinion, obtain very important results in explaining this phenomenon.

Regarding the performance of the 603 firms in our sample, the three-year period post-IPO equal weighted buy and hold return of 26.2% is on line with the four benchmarks being compared. When we analyse this return by year of issuance, our evidence leads us to agree with Ritter (1991): the underperformance phenomenon is not as general as the underpricing phenomenon. Using Calendar Time Results, the evidence in favour of underperformance is even smaller.

However, our Event Time Results show that underperformance is a phenomenon that occurs in the technology industry for smaller IPOs, with gross proceeds under $50 million; for those that had a negative return on the first day of trading; and for younger firms, under the age of six at the time of the IPO.

Fama and French (1993) three factor time series regression using all sample, evidence the existence of underperformance (-10.3 basis points per month, about -1.24% per year). Although our results show a lower level of underperformance than the results of other authors, it does not mean that underperformance does not exist for our sample. The evidence in favour of underperformance is even greater for the results of the Fama and French (1993) model using some subperiods: for example, from February 2001 to December 2008, an intercept of -0.203 is -20.3 basis points per month, about -2.463% per year.

The underperformance that we believe that exist in our sample is not, in our opinion, a sign of overreaction on the first trading day. According to our Event Time Results, the IPOs that underperform, on average, are those that were not underpriced on the first trading day, it means, are those whose first day initial return is less than or equal to zero. Those who found underpricing on the first day, that is, whose first day close price was higher than the offer price, have wealth relatives greater than 1, either when compared to Nasdaq Composite or when compared to Nasdaq 100 Tech Sector, thus showing no signs of underperformance.

To conclude, our results seem to show a very interesting conclusion: both underpricing and underperformance phenomenon are present in our sample, however there seems to be no sign of overreaction. On the contrary, IPOs who perform the worst on day one are also the worst performers over the next three years.

8. Appendices

8.1. Appendix A - Descriptive Characteristics of Sample IPOs

Table 18 - Mean Gross Proceeds, Median Gross Proceeds, Mean Amount of Money Left on the Table, and Median Amount of Money Left on the Table, by Cohort Year, 2001 to 2019

This table presents some descriptive statistics of the IPOs in our sample. The gross proceeds of each IPO are equal to the amount raised from investors in the offering; it means it is equal to the offer price times the number of shares issued. For each IPO, the money left on the table is calculated as the difference between the first day closing price and the offer price multiplied by the number of shares issued. The gross proceeds and the money left on the table were calculated for 601 from our sample of 603 IPOs, due to lack of information. Information related to the offer price and first day closing price is from IPOScoop.com research site and the number of shares issued is from the Nasdaq website.

Year	Mean Gross Proceeds, $ Millions	Median Gross Proceeds, $ Millions	Mean Money Left on the Table, $ Millions	Median Aggregate Money Left on the Table, $ Millions
2001	303	63	21	14
2002	131	71	9	7
2003	125	85	19	18
2004	145	70	23	3
2005	150	75	10	4
2006	125	83	19	6
2007	159	96	39	13
2008	222	153	-19	-19
2009	290	120	52	30
2010	145	91	8	6
2011	254	94	59	17
2012	583	92	41	16
2013	201	105	77	21
2014	177	100	36	15
2015	247	99	34	10
2016	118	91	40	12
2017	239	98	82	17
2018	256	177	84	55
2019	619	163	176	103
Total	214	93	39	12

8.2. Appendix B - Performance categorized by Subsector

Table 19 - Three Year Post-IPO Equal Weighted Buy and Hold Returns and Wealth Relatives categorized by Subsector

The 3-year buy and hold returns are the total return from a buy and hold strategy where a stock is purchased at the end of the first trading day after the IPO and is held for three years (or until the delisting date or until June 2019 if any of these moments occur before the IPO's third anniversary). The 3-year buy and hold return of each IPO is calculated as explained in section 3.1.2.1. These returns are compared with alternative benchmarks. The return of each benchmark was calculated for several different periods, corresponding to the same period for which the returns of each IPO are calculated. The wealth relative is the ratio of one plus the average IPO 3-year holding period return by one plus the average 3-year holding period return of the respective benchmark. For each company, we manually searched for its SIC code using the SEC website. Ultimately other databases were also used, such as Orbis from Bureau van Dijk, *Datastream* database and the Nasdaq website. We use the same classification as Loughran and Ritter (2004) as explained in section 3.2. Data to calculate returns is from *Datastream* database and allows us to calculate the return of 568 IPOs from the 603 companies in the sample. The NASDAQ-100 Technology Sector Index began on February 22, 2006, so it can only be compared with the 419 IPOs that took place after that date and for which we have data.

Subsector	Number of IPOs	Average 3-year holding period total return		Wealth Relative	Number of IPOs	Average 3-year holding period total return		Wealth Relative
		IPOs	Nasdaq Composite			IPOs	Nasdaq 100 Tech Sector	
Computer Hardware	23	3.4%	23.1%	0.84	19	-2.0%	31.8%	0.74
Communications Equipment	22	-17.2%	22.7%	0.67	18	-13.4%	30.8%	0.66
Electronics	73	23.7%	22.2%	1.01	47	28.4%	33.1%	0.96
Navigation Equipment	2	-38.6%	30.8%	0.47	1	-46.9%	32.0%	0.40
Measuring and Controlling Devices	14	-1.3%	23.9%	0.80	9	16.7%	24.8%	0.94
Medical Instruments	89	3.3%	19.8%	0.86	58	-3.1%	30.0%	0.75
Telephone Equipment	14	12.5%	4.5%	1.08	7	-8.5%	20.0%	0.76
Communications Services	13	-15.5%	23.6%	0.68	8	-20.3%	28.6%	0.62
Software	254	45.6%	29.6%	1.12	206	53.8%	40.5%	1.09
Others	64	26.4%	22.2%	1.03	46	26.9%	29.3%	0.98
	568				419			
Mean		26.2%	24.9%	1.01		31.2%	35.3%	0.97
Median		0.4%	28.4%	0.78		0.5%	37.0%	0.73

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