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Ex ante and ex post uncertainty to explain underpricing that is inherent to Initial Public Offerings: Evidence from the United States for the period including the financial crisis 2003 – 2013

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Abstract

Initial Public Offerings (IPOs) have been around for as long as the day is long and inherently to this is the underpricing or the initial return. The research done regarding this phenomenon is clear and convincing: regardless the period, underpricing is persistent and is widely seen across the globe. So far, scholars only looked at ex ante variables (e.g. age, sales) to explain this. However, recent literature also points at ex post uncertainty, as not all uncertainty is resolved once the trading begins. In this paper I use both ex ante and ex post variables to explain underpricing. Including those proxies that resemble ex post uncertainty I find that the explanatory power of those models nearly doubles when compared to a model where only ex ante variables are included. Attention is also given to IPOs conducted after the financial crisis and the results indicate that after-crisis IPOs contain more uncertainty leading to a higher degree of underpricing.

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1. Introduction

Underpricing is present when the first-day return is positive, i.e. when the closing price on the first day of trading is higher than the offer price. Underpricing can also be measured using the closing price after a week, or even a month of trading. In this paper I will use the first-day closing price. Viewing an IPO through the eyes of the company that conducts it, underpricing is obviously bad in the sense that the company could have raised more capital. After all, that is one of the important reasons why an IPO is undertaken in the first place. However, viewing any IPO through the eyes of those participants who were able to obtain the company's stock for the offer price, that same underpricing is perceived as an initial return. Throughout this paper I will use underpricing and initial return interchangeably.

More remarkable is that underpricing has been a persistent phenomenon over the years for dozens of countries. Loughran, Ritter, & Rydqvist (1994), keep an updated paper that lists the average initial return for 52 countries for different time periods. For the Netherlands (1982 – 2006) this underpricing was 10.2%. Similar results are observed for Germany (1978 – 2011): 24.2%, United Kingdom (1959 – 2012): 16.0%, South Africa (1980 – 2013): 17.4%, Nigeria (1989 – 2013): 13.1%, Iran (1991 – 2014): 22.4%, Indonesia (1990 – 2014): 24.9%, Japan (1970 – 2013): 41.7%, Australia (1976 – 2011): 21.8% and the United States (1960 – 2014): 16.9%. Surely IPOs occur where the initial return is (close to) zero or even negative, but for the *average* IPO this is not the case.

As for so many countries with an average positive initial return, there are at least as many scholars who tried to explain this occurrence and four main theories have been developed. The most established theory is based on an asymmetric information model. In this model the issuing firm, the underwriting bank and the investors buying the stock are the three key parties. It is then assumed that not all parties are equally informed regarding the true value of the shares. If the investors buying the stock are the uninformed party, for whatever reason, they are subjected to the winner's curse (Rock, 1986). In this asymmetric model that Rock develops, the uninformed investors bid on any IPO regardless its attractiveness. For overpriced IPOs, uninformed investors receive all those overpriced shares since *informed* investors know better and did not bid in the first place. Although these investors may by uninformed, they are still rational and require a compensation for their uninformed-ness in the form of the initial under-pricing. In the Literature Review, this theory along with the three other main ones will be further discussed.

This model of Rock (1986) is formalized by Ritter (1984) and Beatty & Ritter (1986). They argue that an (uninformed) investor who submits an order to purchase the company's shares cannot be certain about the shares true value. They deem this uncertainty the ex ante uncertainty. It is then logical to link this to the underpricing as more uncertainty requires the investors to be additionally compensated in the form of a higher initial return. As more (un)certain IPOs cannot be readily observed, ex ante uncertainty variables are formalized that serve as proxies to capture this uncertainty.

The stream of literature that tried to explain underpricing did so with ex ante variables. More recent literature however also argues that the uncertainty regarding the value of an IPO is not resolved once the IPO starts trading (Chen & Wilhelm, 2008). In their model they assume that information regarding the value of the IPO's shares continues to arrive even after the book-building process[1] has ended. Because this new information has not been processed yet, uncertainty remains even after the IPO has been conducted that is labelled ex post uncertainty. Another view comes from Draho (2001), where the author argues that secondary market value does not represent the true value of the IPO as assumed by Beatty & Ritter (1986). Draho (2001) provides evidence that when the information produced in the primary market[2] increases (i.e. qualitatively and quantitatively) the ex post uncertainty, and therefore the underpricing decreases. In the model from Saar (2001) it is established that this ex post uncertainty is linked to a measureable bid-ask spread. Together Saar (2001), Draho (2001) and Chen & Wilhelm (2008) inspire Falconieri, Murphy, & Weaver (2009) to develop proxies for ex post uncertainty.

Empirical literature is very clear concerning underpricing and indicates that it is persistent over time for a lot of countries. Thus far, those papers only looked at the ex ante variables to try to explain this under-pricing, ignoring the fact that ex post uncertainty might also be a present. In that regard the existing literature is leading for the basis regression in this paper. In order to supplement, new proxies are explored and discussed that have not been considered as much. This paper is therefore three-fold: (i) to show that ex ante variables still explain a large portion of the underpricing, (ii) provide evidence that the, 'relatively unknown' proxies for ex post uncertainty are indeed good proxies and (iii) to provide evidence what additional effect the financial crisis has on underpricing. These goals are achieved by starting off with a basis regression that only includes ex ante variables. This basis regression is then expanded by inserting different constructed proxies for ex post uncertainty. A t-test of difference will confirm why certain variables interact with the crisis dummy to assess the potential additional effect on underpricing.

I find that using the established ex ante variables to capture uncertainty still hold to explain the underpricing. In developing ex post uncertainty variables I find that the standard deviation of quoted midpoints is the best proxy in terms of R^2. Compared to the basic model that just contains ex ante variables the explanatory power of the model increases by 15%. Segregating this proxy in the first two hours and the remainder of the first trading day nearly doubles the R^2 compared to the basic model. Another proxy that provides similar results is the standard deviation of quoted midpoints divided by the offering price. Although the R^2 is lower, the coefficients corresponding with the ex ante variables remain significant and with the anticipated sign, compared to the basic model. Correcting for the financial crisis by interacting certain pre-determined variables with a crisis dummy led to significant results and showed that more ex post uncertainty exists after the crisis leading to a higher initial return.

This paper therefore contributes to existing literature and shows that ex ante variables still explain a great deal of the persisting underpricing. Moreover, as suggested by Chen & Wilhelm (2008), value uncertainty is not resolved once the IPO starts trading and is named ex post uncertainty. Proxies to capture ex post uncertainty are developed by Falconieri, Murphy, & Weaver (2009) and used in the regressions. The results in this paper suggest that these proxies are indeed good proxies and confirms Chen & Wilhelm (2008) their theory that the book-building process generates additional information. Due to the narrow

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[1] The book building process is the process where the underwriter leading the IPO has to determine at what price the shares will be offered. This is done based on the demand of institutional investors.

[2] The primary market represents the market participants who buy the shares 'first'. These participants are institutional investors like pension funds or life insurance companies.

time-frame of this process this information is not incorporated into the market. This implicates that the book-building process might has to be revised or explore different forms of book-building. Regarding the theory of Draho (2001), the results suggest that once the quality and quantity of the information in the primary market increases, the uncertainty in the secondary market and therefore the underpricing decreases.

The remainder of the paper is organized as follows. In the next part the four most established theories concerning underpricing are discussed. This section also contains the hypotheses. Section 3 lists the databases and the methodology to arrive at the variables. Part 4 then provides tests to determine what variables should interact with the crisis dummy and outlines the results. The final section concludes and addresses any concerns regarding the results and provides suggestions for further research.

2. Literature Review and Hypotheses

2.1 Literature Review

Systematic underpricing was already observed in the early literature (Stoll & Curley, 1970), (Reilly, 1973) and (Ibbotson, 1975). For decades this underpricing has captured the attention of scholars. Not only because it is a persisting phenomenon, but also because this suggests that companies conducting IPOs, leave considerable amount of money on the table. Ritter has an overview of those numbers[3]. This amount is calculated by taking the absolute difference between the offer price and the first-day closing price and multiplying that by the amount of shares offered. To give the reader a general idea about the magnitude of these amounts I list some of the more well-known companies and the amount of money-left-on-the-table between brackets. Visa ($5 bln.), Google ($300 mln.), Groupon ($209 mln.) and McAfee ($200 mln.). Clearly this makes underpricing an interesting area of research as it is interesting to find out why these amounts are generally a rule rather than the exception.

Three key parties are involved in an IPO: (i) the issuing firm, (ii) the underwriter and (iii) the investors buying the stock (Ljungqvist, A., 2005). The author also mentions that theories explaining underpricing can be (sub)divided under four main headings. The first header is *asymmetric information* where one of the parties involved knows more than the other. The second header is *institutional theories* that focuses on litigation, banks' price stabilization activities and taxes. *Control theories* assume that underpricing helps shape the shareholders base so outside shareholder intervention is reduced. The last header regards *behavioural aspects* that assumes irrational investors. While the lion part of empirical evidence points to information asymmetry as the main reason of underpricing, it is debated whether this can be the only reason for such consistent underpricing over the years. In parts 2.1.1 till 2.1.4 I will globally discuss these four main headers that explain the underpricing and starting from paragraph 2.2 I will explain why and on which theory this paper will focus.

[3] https://site.warrington.ufl.edu/ritter/files/2015/08/Money-Left-on-the-Table-in-IPOs-by-Firm-2015-08-04.pdf

2.1.1 Asymmetric information theory

Three parties concerning the IPO play a role, the underwriting bank, the issuer and the investors. It is assumed that one of these parties knows more than the other. Baron (1982) argues that the underwriting bank is the more informed party regarding demand, which leads to underpricing to increase the selling effort. Welch (1989) assumes that the issuer is better informed about the true fundamental value of the firm and therefore underpricing serves as a signal to indicate a higher-valued firm. Another theory is that of Rock's (1986) winner curse. In this paper he argues that some investors are better informed than others and that these investors who are not as well-informed always pay too much and are subjected to the winner's curse. This has to be countered with underpricing.

2.1.2 Institutional theory

Theories that fall under this header focus in general on three features of the marketplace: litigation, banks' price stabilization activities once trading starts and taxes. The details regarding the institutional framework differ in such ways that should allow sharper tests of theoretical predictions. In the U.S., for instance, IPOs are conducted in the following way. Once the issuing firm decides on its lead-underwriter it files a registration statement with the Securities and Exchange Commission (SEC), containing all (historical) fundamental analysis. Once the SEC approves, the lead-underwriter goes on a so called road-show where it outlines the issuing firm's investment case to institutional investors. On the basis of certain indications of interest, which are recorded in a 'book' and the state of the general market, the lead underwriter proposes an offer-price to the issuing firm. Once a price-range has been established, institutional investors are asked to confirm their indications of interest and eventually trading begins.

Taiwan on the other hand does not permit book building for instance, but instead IPOs are priced based on investor's bids and investor pay what they bid. And even though the way in which IPOs are conducted become more homogenously around the globe (Ljungqvist, Jenkinson, & Wilhelm Jr., 2003), institutional frameworks do still differ and more research is needed.

Since the scope of this paper concerns IPOs conducted in the U.S. only, no attention is given to the institutional framework.

2.1.3 Control theory

A third theory concerns the separation of ownership and control. This is inevitable when conducting an IPO. A problem that arises with this separation is agency problems between managing and non-managing firms (Jensen & Meckling, 1976). It is where management does not act in the best interest of the shareholders, but instead pursue their own goals, like empire building. Two models are developed to test this theory. The first model is developed by Brennan and Franks (1997). They rationalize that underpricing is a way for managers to protect their private benefits. By underpricing excess demand is created that leads to a more widely dispersed ownership. With more investors holding smaller stakes in the business this leads to (i) a reduced threat of being ousted in a takeover (Grossman & Hart, 1980) and (ii) those investors investing in a lower level of monitoring. The second model contradicts the first model. Stoughton & Zechner (1998) argue that managers should not want to maximize private benefits of control as these agency costs will be eventually borne by the owners itself. In this light it would be more beneficial to allocate shares to a large outside shareholder to encourage monitoring. In the end, monitoring is a public good that will benefit all shareholders. Although this is a promising theory, more empirical evidence is needed to shed light on these two opposing models.

2.1.4 Behavioural Theory

The final theory is still in its infancy and concerns the behavioural angle. These theories assume that either the investors are irrational that bid up the price of IPOs or that the issuers are prone to certain biases and so fail to pressure the lead underwriter to reduce this under-pricing. Ljungqvist, Nanda, & Singh (2006) were the first to capture the investors' irrationality or investors' sentiment as they call it. They assume that sentiment investors hold too optimistic believes about the future developments of the company. Issuers take advantage of this by supplying just the right amount of shares to not flood the market and put a downward pressure on the price. In the long-term the real prospects of the company reveal itself and the price return to their corresponding value. This is actually observed regarding the second anomaly of IPOs: the long-term underperformance.

Loughran and Ritter (2002) provide another explanation for under-pricing that involves the issuers of the firm. Combining prospect theory with the idea of mental accounting make these authors argue that issuers cannot be upset about leaving millions of dollars on the table as they substitute the losses they make with the gains they perceive with the retained shares. Moreover, before an IPO is conducted the issuers have a believe regarding the value of an IPO that is within a certain range, but somehow the lead-underwriter managed to alter the issuers reference point (their believes). This theory is then tested in Ljungqvist & Wilhelm (2005), but in order to say how this affects underpricing more work is needed.

2.2 Information asymmetry

Ex ante Uncertainty

These main theories concerning underpricing are all very extensive and it would be too much to cover all this in one single paper, therefore I will focus on the most established theory regarding underpricing namely that of *information asymmetry.*

Recall that three key parties are involved in an IPO: the issuing firm, the lead-underwriter and the investors buying the stock. I narrow this this down to information asymmetry among investors buying the stock. The theory originates from Akerlof (1970) with his lemons problem. He points out that in a market for second-hand cars, the 'good' cars are filtered out since buyers of cars have an informational disadvantage over sellers who sell 'bad' and 'good' cars. This results in an average price of cars that is lower than what 'good' cars are worth. The same line of reasoning is applied by Rock (1986) in his paper "why new issues are under-priced" (formalized earlier in his Ph.D. dissertation in 1982). In his model the true value per share *'v'* is uncertain for the issuing firm, the underwriter and the investor. For a cost the investors can learn the value per share '*v*'. Once uninformed investors incur this cost they are deemed the "informed investors". Logically these informed investors will only purchase shares when the offer price is below '*v*'*.* While informed investors only bid for attractive IPOs, uninformed investors bid for every IPO regardless its attractiveness. This implies that for unattractive IPOs these uninformed investors receive all the shares, but also implies that for attractive IPOs they do not receive all the shares, since informed investors would have offered a higher price. Since investors know whether they are (un)informed, uninformed investors are not willing to bid for IPOs and require a discount in the form of a lower offer price, that is the initial underpricing. This is Rock's winner's curse.

Another assumption Rock (1986) makes is that the primary market[4] for IPOs depends on the participation of uninformed investors in the secondary market, since informed demand is insufficient to account for all the shares concerning the IPO. In other words, the participation on uninformed capital is needed for the continuance of IPOs.

Implicitly Rock states that for underpricing to persist the market for IPOs consist of heterogenetic investors. Michaely and Shaw (1994) argue that if this assumption is relaxed in a way that all investors are equally informed, the winner's curse would disappear and so would the underpricing. They look at IPOs of master limited partnerships (MLPs), which are ignored by large institutional investors. If institutional investors are mainly informed, the heterogeneity among investors in those MLPs should be low. With this type of IPO they find that the average underpricing is -0.04%. This is in sharp contrast with the literature that finds average underpricing of 16.9% for U.S. IPOs from 1960 to 2014 (Loughran, Ritter, & Rydqvist, 1994).

In response to Rock's winner's curse, Ritter (1984) states that underpricing is a compensation for the investor that incurred costs to get to know the true value of the shares, like understanding the company's fundamentals. Moreover he argues that if this uncertainty regarding *'v'* increases, the greater the costs for the uninformed investors, the greater the compensation should be which results in an even larger degree of underpricing. So, the riskier initial offerings are in terms of value uncertainty regarding the shares, the more severe is the accompanying underpricing.

It is then logically to think about what defines a risky IPO (again: in terms of value uncertainty). As we cannot simply observe risky IPOs, certain proxies have to be developed that resemble this value uncertainty concerning an IPO. Over the years many proxies have been established by previous literature. These proxies (or variables) that have been used can be observed before the IPO has been conducted. Examples are the age of the firm or the revenue. These variables are named ex ante variables that in turn represent the *ex ante uncertainty* regarding the IPO. To complement that stream of literature that established these ex ante variables that proxy for ex ante uncertainty, more recent literature also points *to ex post uncertainty*.

Ex post Uncertainty

As claimed by Ritter (1984) there is no reason to only look at ex ante uncertainty to explain underpricing and accordingly restrict explanatory variables that have this classification (e.g. age). In his paper, for instance, he uses the standard deviation of the after-market return as a proxy for uncertainty.

More recent literature caught up to this fact as it is reasonable to suggest that uncertainty regarding the value of an IPO is *not* resolved once this IPO starts trading (Chen & Wilhelm, 2008) and (Draho, 2001).

[4] Institutional investors like pension funds

The value uncertainty remaining after the IPO has been conducted is deemed ex post uncertainty (Falconieri, Murphy, & Weaver, 2009).

Chen and Wilhelm (2008) provide one view on why uncertainty remains after the IPO has been conducted. They indicate that the offer price is determined by the effort of the underwriter to build a book of investors with the amount and price each potential investor want to purchase. It is then argued that not all possible information is incorporated into the offer price because of the narrow time frame of the book-building process. The actions of the issuing firm *during* the book-building process triggers more, new information that arrives after the process has already finished. This leads to the ex post uncertainty regarding the underpricing of IPOs.

Another view on why there is ex post uncertainty comes from (Draho, 2001). In his paper he starts with the assumption from Beatty & Ritter (1986). They argued that uncertainty was present regarding the firm value, with the assumption that the secondary market price would represent the true value of the firm. Draho (2001) relaxes that assumption and instead assumes that the secondary market price is conditional on investor's belief and information they receive. His results suggest that uncertainty in the secondary market decreases when the quality and quantity of the information produced in the primary market increases. So is not the uncertainty regarding the true value of the IPO, but rather uncertainty regarding the secondary market value. This view from Draho (2001) is another reason that uncertainty exists after the IPO has been conducted, namely the ex post uncertainty.

Now I have established that there is such thing as ex post uncertainty the next step is to be able to quantify this ex post uncertainty. As with ex ante uncertainty, variables have to be developed that represent this uncertainty. The starting point is Saar (2001), where the author develops a model where he demonstrates that bid-ask spread and uncertainty about the investor demand in the secondary market are directly related. The papers from Chen & Wilhelm (2008) and Draho (Draho, 2001) *together* with the paper from Saar (2001) establish that ex post uncertainty can be measured by looking at the bid-ask spread in the secondary market. The final step is specifying exact variables that measure this bid-ask spread and is done by Falconieri, Murphy, & Weaver (2009) in the methodology section of this paper.

2.3 Hypotheses

Keep in mind that all variables that are listed influence the uncertainty regarding the true value of a share. The more uncertain (the riskier) an IPO, the higher the initial underpricing and so the higher the initial return for investors participating in an IPO. Since I do not observe the costs incurred by investors to get informed I cannot say what their net return is, this ties together with the rationale that some investors are most likely informed in different ways and with different degrees of effort.

The numerous proxies that have been used in preceding literature can be categorized into four groups: company characteristics, offering characteristics, prospectus disclosure and aftermarket variables. In addition to these four groups, a fifth group is added that is labelled "ex post uncertainty". Even though aftermarket variables and ex post uncertainty denote the same line of variables (namely variables after the IPO has already been conducted), this distinction is still made for clarity and to emphasize the extension from previous conducted research. In the next parts I will develop hypotheses regarding what variable will affect the underpricing in what direction. For clarity a sign between parentheses for each variable is shown to indicate whether it increases (+) or decreases (-) the initial underpricing. Recall that an increase in the underpricing means that the initial return increases.

2.3.1 Company characteristics

(1) Company Age (-)

In establishing a company's true value at the time of an IPO, Ritter (1984) suggested to use age as a proxy to measure uncertainty. Intuitively it makes sense that the older the firm, the more experienced that company is. According to Firth & Smith (1992) and Lee, Taylor, Yee & Yee (1993) older firms have a better understanding of the effect of the environment on future performance and better control over their operations. This in turn leads to more accurate forecasts of the firm's future performance (Jaggi, 1997). Since these more accurate forecasts are disclosed in the IPO-prospectus they assist potential investors on making a better estimate on the IPOs true value. In addition, younger firms will have fewer years of financial statements and have not yet been scrutinized as much by financial analysts (Rasheed, Datta, & Chinta, 1997). Both better estimates of future performance and the presence of more financial statements by older companies leads to less uncertainty and so decreases the degree of underpricing needed. And so I hypothesize:

Hypothesis 1: The age of the company will be negatively associated with underpricing

(2) Company Size (-)

In Finkle (1998) the author states that larger companies have access to a bigger pool of resources and therefore can more easily find those resources that are critical to the firm (e.g money and human capital). This in turn increases the survivability of the firm. It is also argued that larger companies have more expertise and more sophisticated forecasting techniques to arrive at more accurate forecasts of financial performance (Eddy & Seifert, 1992) and (Mak, 1994). As with company age this leads to a better assessment of the IPO's true value. The increased survivability and more accurate forecasts leads to less uncertainty and decreases the degree of underpricing. Therefore I hypothesize:

Hypothesis 2: The size of the company will be negatively associated with underpricing

2.3.2 Offering characteristics

(3) Gross proceeds (-)

In the paper of Tinic (1988) the size of the offering is used as a control variable, since small issues are mostly offered by small start-up firms who in turn are more speculative issues. Large companies on the other hand are associated with less uncertainty regarding the IPO. Two possible reasons for excluding this variable arise. One is that gross proceeds are highly correlated with the size of the company, as it is only logical that firms with more revenues or assets have higher gross proceeds. However, this does not always have to be the case since the gross proceeds in turn depend on how well a company's true value can be estimated on basis on their fundamentals. If in the case of technological companies, the value cannot be accurately estimated, gross proceeds could be a proper explanatory variable. The second reason is provided by Habib and Ljungqvist (1998) and intuitively makes sense. They explain and provide evidence that the IPO proceeds are strictly increasing in the number of shares, while the effect on issuing more shares results in higher losses that are implied by issuing more shares at a discount. So it is not the seasoned companies that are associated with lower underpricing, but the dilution of shares due to the overallotment option[5]. Even though this variable is disputed as an explanatory variable, I include this variable for completeness and I hypothesize:

Hypothesis 3: The gross proceeds will be negatively associated with underpricing

(4) Venture backed (-)

Start-up companies do not have the financial history to prove or the have collateral to guarantee that they might be a profitable investment. This presence of asymmetric information makes corporate governance important (Gompers, 1995). In Amit, Brander, & Zott (1998) the authors state that venture capitalists are financial intermediaries that have developed a comparative advantage when it comes to information asymmetry. By monitoring, venture capitalists gain detailed knowledge of the companies they invest in and limit the opportunistic behaviour of the entrepreneurs (Lerner, 1995). In Megginson & Weiss (1991) they provide evidence that the presence of venture capitalists in an IPO can certify that the offering price reflects all available and relevant information. More importantly, the presence of venture capitalists reduces the initial underpricing and in addition lower the cost of going public. It is therefore hypothesized:

Hypothesis 4: Venture capital backed IPOs will be negatively associated with underpricing

(5) Underwriter's reputation (-)

The role of the underwriter is important in two ways; (i) to advise the firm on the price and (ii) to sell the stock (Allen & Faulhaber, 1989). In the paper of Carter & Manaster (1990), they build a model where they argue that between issuing firms there is a dispersion in their possible secondary market values, which is denoted as sigma. An issuing firm's stock is perceived as less risky if it has a lower dispersion and this issuing firm would like to signal this. One way of doing that is by selecting underwriters with high prestige. So in order to let investors know that their secondary market values are not widely dispersed, an issuing firm contracts underwriters with a reputation for marketing the IPOs of low dispersed firms. Prestigious underwriters in turn are adept in identifying sigma, and avoid firms with high dispersion in order to maintain their high reputation.

One way of measuring the underwriter's reputation is the position of each underwriter in the tombstone announcement (Monroe, 1986). A tombstone announcement is a listing of a pending public security offering, with in addition investment bankers that underwrite the IPO. The position of the underwriter in the tombstone announcement is highly subjected to a rigid hierarchy (Hayes, 1971) and is perceived as very important up to the point where underwriters would even back out of a very profitable

[5] The overallotment option enables the underwriter to purchase additional shares from the issuer at the offer price. This is done when there is excess demand.

deal if underwriter's position does not correspond with their reputation. Those underwriters at the top are the most prestigious, while the least prestigious underwriters are at the bottom. The underwriters are then assigned a rank in line with their position in the tombstone announcement. The result is a scale from zero (least prestigious) to nine (most prestigious) that measures the underwriter's reputation (Carter & Manaster, 1990). I hypothesize:

Hypothesis 5: The reputation of the underwriter will be negatively associated with underpricing

(6) Hot (+) or Cold (-) IPO Markets

Ritter (1984) describes certain periods when there are many IPOs as hot-issue periods and when there are few IPOs as cold-issue periods. It is then logical to ask what defines 'many' and what defines 'few', as this should be benchmarked. In Ritter (1984) the author explains and that Rock's model concerning the winner's curse can be illustrated by a positive relationship between risk and the initial return (underpricing). Ritter calls this the *changing risk composition hypothesis.* He then defines a hot-issue period if during a given time period a large proportion of firms going public have high risk (and so high initial underpricing) and cold-issue period as a time period where a large proportion of firms conducting an IPO have low risk (lower initial underpricing). Both periods have their own, but opposite hypothesis:

Hypothesis 6a: In the case of hot-issue period, this will be positively associated with underpricing
Hypothesis 6b: In the case of cold-issue period, this will be negatively associated with underpricing

2.3.3 Prospectus disclosure

(7) Number of uses of proceeds (+)

The uses of the proceeds are listed in the prospectus. These uses should contain detailed information for investors on how the invested money will be put to use. However, firms are reluctant to give detailed specifications because of (i) increased exposure to legal liability and (ii) disclosure of proprietary information to competitors (Beatty & Ritter, 1986). Regulation from the Security and Exchange Commission (SEC) made this variable a particular good proxy for ex ante uncertainty. The SEC required more speculative IPOs to provide more detailed information regarding the uses of the proceeds, while less speculative issues were not required to do so.

Beatty and Welch (1996) on the other hand argue that the number of uses of proceeds is a noisy measure as some uses are quite well specified, while other uses are vague and are not informative like 'secondary'. I will come back to this issue and try to resolve the problem mentioned by Beatty and Welch in the methodology section of this paper. Based on the SEC-regulation it follows that when more uses of proceeds are listed, more uncertainty exists regarding this IPO, which should lead to a greater degree of underpricing. It is therefore hypothesized:

Hypothesis 7: The number of the uses of proceeds will be positively associated with underpricing

2.3.4 Aftermarket variables (ex post uncertainty)

(8) Standard deviation (+)

The standard deviation of returns in the secondary market indicate that there was ex ante uncertainty regarding the value of the firm (Ritter, 1987). It makes sense that when the return in the secondary market is more volatile, this is an indication that, apparently, it is harder for investors to correctly valuate the company's stock. More uncertainty in turn would require a higher initial return for the investors in the form of a higher degree of underpricing. Therefore I hypothesize:

Hypothesis 8: The after-market standard deviation will be positively associated with underpricing

Jenkinson & Ljungqvist (2001) argue that the standard deviation of the aftermarket return as a proxy for ex ante uncertainty is not an adequate proxy as a higher standard deviation also reflect the relationship between risk and return. As it is still a widely used proxy for uncertainty, I include this variable in the regression.

(9) Trading Volume (+)

Miller & Reilly (1987) provide evidence that trading volume in the after-market indicates that there is higher uncertainty regarding the true value of the stock. So I hypothesize:

Hypothesis 9: The after-market trading volume will be positively associated with underpricing

2.3.5 Ex post uncertainty

(10) Proxies for ex post uncertainty (+)

To complement the stream of literature on ex ante uncertainty, three proxies for ex post uncertainty are developed to account for the persisting uncertainty even after the IPO has been conducted. These proxies are formalized in the methodology section, but since they are directly related to underpricing I hypothesize:

Hypothesis 10: The proxies for ex post uncertainty will be positively associated with underpricing

3. Data and Methodology

In this section data and methodology are presented. Paragraph 3.1 deals with the databases that will be used and what criteria shrank the number of observations. Subparagraph 3.1.4 gives an overview of the descriptive statistics are subparagraph 3.1.5 presents all the variables used in the regressions. In section 3.2 the methodology is explained.

3.1 Data

In order to obtain all the required data, several datasets are being used: Thomsonone, Datastream and the Trade and Quote database (TAQ). The TAQ-database is part of the Wharton Research Data

Services. Before turning to Datastream and TAQ a pre-selection is being made within Thomsonone. Subparagraph 3.1.1 will deal with Thomsonone and subparagraph 3.1.2 will focus on Datastream and TAQ. Paragraph 3.1.3 will give a definition of the pre-, during and post-crisis periods. Paragraph 3.1.4 will deal with the descriptive statistics and paragraph 3.1.5 will give an overview of the variables that are used in the regression analysis.

3.1.1 Thomsonone

Period-wise I am interested in IPOs that occurred between 2003/07/01 and 2013/12/31. The beginning date is chosen as it indicates the end of the internet bubble that occurred around the millennial. It is based on the observation that the relationship between the price of the S&P500 and the dividends per share hold in the long-term (Ironman, 2007). This relationship re-emerged in June 2003 indicating the end of the internet bubble and therefore the 1st of July 2003 is chosen as the beginning date. The ending date is chosen based on the availability of data in the TAQ-database that has intraday stock data up until December 2013.

In *Table 1* an overview is given how many observations were removed and for what reason. In the following paragraphs the numbers in bold **(X)** correspond with the numbers in *Table 1*. Without making any adjustments for missing or incomplete data, 2102 observations are obtained from Thomsoneone. Of those, 638 (30%) observations have missing founding dates. Founding dates are needed to calculate the company age. The number of observation with missing founding date is quite large and this has been observed before by Field & Ritter (F&R). F&R established an excel file (available on Ritter's site)[6] with the founding dates of 12.719 companies that went public between 1975-2015 (updated till February 2017). By using the additional data of F&R I have been able to only delete 443 observations **(1)** (compared to 638 before). Apart from the additional founding years, I was able to double check the founding data since 231 out of the 1691 observations (14%) did not had matching founding years. Eventually I ended up recovering 200 (87%) out of the 231 not-matching-founding-data observations. This recovering occurred by checking the company's history to determine its correct founding year. I believe that using two different datasets to supplement and correct for not matching founding years will make a more robust empirical analysis.

Other adjustments were made that shrank the size of the data. The biggest chunk was deleting observations that were reverse Leveraged Buy Outs (LBOs) **(2)**[7]. As done by earlier scholars, these forms of IPOs are excluded. Another 199 observations are deleted since those companies had an age (calculated as subtracting the founding year from the year of the IPO) of either zero or even negative **(3)**. Moreover, it has been established that financial companies are a different breed of IPOs than operating companies (Barry & Jennings, 1993). Therefore, 169 observations were deleted with a SIC-code between 6000 and 6800 (financials). Those particular companies consist of banks, insurance companies, real estate and

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[6] https://site.warrington.ufl.edu/ritter/ipo-data/

[7] LBOs are companies that have been taking private in the past, by using relatively a lot of debt (60%-70%)

mutual funds **(4).** Furthermore, 137 observations were deleted because of spin-offs[8] **(5)**. Not having a SEDOL[9] was the last criteria that substantially shrank the size of the dataset **(6)**.

Other criteria that reduced the size were a share price below 1$ **(7)**, missing values for assets **(8)**, either missing an underwriter at all or the rank of the underwriter was not known **(9)** and finally double observations were removed **(10)**. The sub-final sample consist of **635 observations.**

Table 1: Data shrinkage (1)

Overview of why and by how many observations the initial 2102 observations shrank.

Initial Observations	**# Observations Removed**	**Reason for shrinkage**
2102	443	(1) No founding year
	274	(2) Reverse LBOs
	199	(3) Company age of zero or negative[10]
	169	(4) Financial companies[11]
	137	(5) Spin-offs
	107	(6) No SEDOL-code[12]
	138	(7) SP < 1$[13], (8) Assets, (9) UW-rank and (10) doubles
Sub-final sample: 635 observations		

3.1.2 Datastream and TAQ

Datastream

I require Datastream for three variables: (i) the first day closing stock price, (ii) the first trading volume and (iii) the first 20 days closing stock prices for the standard deviation of the return ($\sigma(R)_{t1-20)}$). *Table 2* outlines why and by how many the sub-final sample of 635 observations from Thomsoneone shrank.

(i) Retrieving the closing day stock prices from Datastream led to a questionable *average* degree of underpricing of near 1700%. The highest degree of underpricing amounted to 630.000%, while at the low end the degree of underpricing was an acceptable -86%. There were around 30 observations that had an initial return of (far) above 1000%. Note that the offer price was provided by Thomsoneone, while the closing stock price on the first trading day was provided by Datastream (the difference is the underpricing). Therefore I decided to retrieve the closing stock price from Thomsoneone as well and where necessary supplement Thomsoneone with Datastream. 44 observations were excluded from the sample because data was available at least one day *before* the initial trade date.

[8] A spinoff is the initial distribution of shares (IPO) by a company representing ownership in a division or subsidiary of the company that will now trade separately from its parent

[9] A SEDOL-code is a unique identifier for each security. These SEDOL-codes are needed to link the ThomsonOne database with the Datastream database.

[10] Negative company age means that the IPO was conducted *before* the founding year of the company

[11] Banks, Insurance Companies, Real Estate and Mutual Funds

[12] SEDOL-codes are needed to match Thomsonone with Datastream

[13] Indicates a penny stock that trades with a price below $1. Penny stocks are highly volatile and illiquid and therefore excluded

(ii)/(iii) The first day trading volume was not available for 24 observations and therefore were excluded from the sample.

Trade and Quote database (TAQ)

The final database that is used is the daily Trade and Quote (TAQ). They provide intraday trades and quotes data for all issues that are traded on the NYSE, Nasdaq and AMEX. This database is used for collecting quoted stock price data from the initial trading day and one day thereafter. 19 observations were removed since TAQ could not return any data for those companies.

Table 2: Data shrinkage (2)

Overview of why and by how many observations the sub-final sample of 635 observations shrank.

Initial Observations	**# Observations Removed**	**Reason for shrinkage**
635	44	Data appearing before the initial trading date
	24	Missing first day trading volume data
	19	Missing TAQ data
Final sample: 543 observations[14]		

3.1.3 Defining pre-, during- and post crisis

Since my data also includes the period of the global financial crisis I choose to define these three periods (pre-, during and post) as this would also show the effect (if any) of the crisis on the initial underpricing. Above all, including this distinction makes a more robust empirical analysis, especially since the financial crisis affected the global financial system and not correcting for such an exogenous event would bias the results.

Undoubtedly did the crisis really took off with the fall of the Lehman Brothers (LBs) in September 2008. Shortly after, American International Group (AIG) suffered a liquidity crisis that led to a downgrade in its credit rating (Block & Sandner, 2009). This in turn affected other financial institutions in the US, stock prices plummeted and the recession began. The paper of Block & Sandler (2009) is taken as a starting point for determining the three different periods, but supplemented with data used in this paper. This makes sense as suggesting that the months prior to the fall of the LBs had nothing to do with the crisis seems a little farfetched. I examine the data based on the three months moving average number of IPOs conducted. The logic for a moving average is straightforward as this corrects for months with fewer IPOs based on seasonality. This methodology is also applied by Helwege & Liang (2004) who mention that January and August are subject to seasonality because of the Christmas- and Holiday period, respectively. *Figure 1* gives this overview of the 3-month moving average number of IPO conducted. Based on this figure the following time periods are defined, see *Table 3.*

[14] The reader might have noticed that this number should be 548. However in defining pre-, during- and post-crisis only 5 observations were available for 'during' and therefore I decided to exclude those observations. I touch upon this in section 3.1.3.

It is important to note that I used the raw, uncleaned data from Thomsoneone to define these three different periods. To be clear, I used the initial 2102 observations as all these observations had a trading-date to determine how many IPO were conducted in a given year and month. For the remainder of this paper, I used the cleaned data as described in parts 3.1.1 and 3.1.2.

Table 3: Pre- during- and post-crisis months

Overview of the pre-, during- and post crisis months.

Definition	**Time-period**	**Number of observations**
Pre-	2003/07 – 2008/07	326
During-	2008/08 – 2009/05	5
Post-	2009/06 – 2013/12	217

As can be seen from *Table 3* the definition of the during-crisis period only delivers 5 observations. As I deem this as too few observations to make any reliable conclusions when including those in the regression, I delete these observations. Moreover, since the periods chosen for the pre- and post-crisis periods might be subjected to some arbitrariness, I move around with those periods and define the following three periods in *Table 4.*

Table 4: Pre- and post-crisis periods

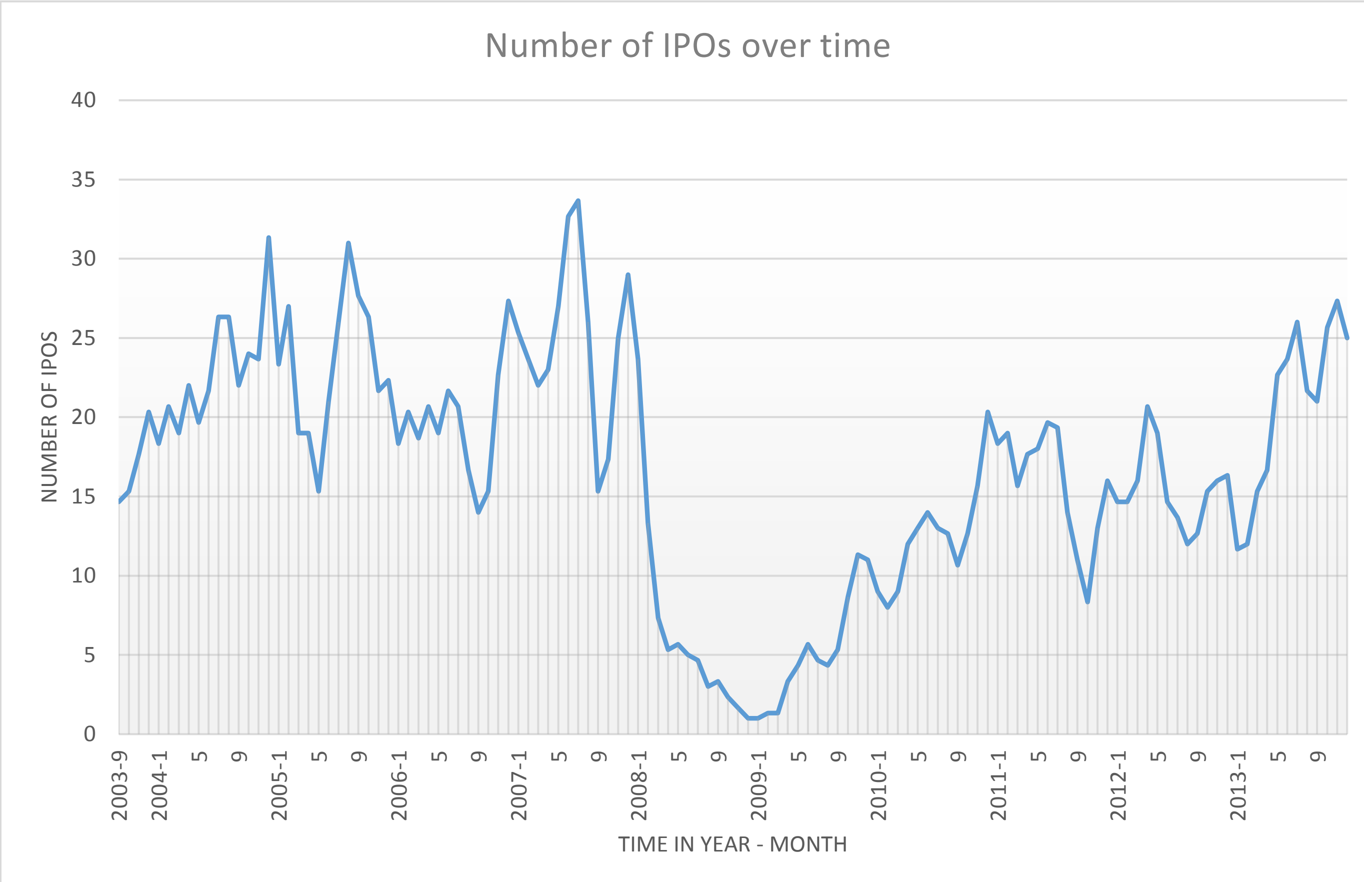
Overview of the pre- and post-crisis periods with the probability of the crisis-coefficient and the adjusted R^2. The crisis dummy takes the value 1 for post-crisis observations.

Method	**Definition**	**Time-period**	**# Observations**	**Probability**	**Adj. R^2**
1	Pre	2003/07 – 2008/07	326	0.613	19.4%
	Post	2009/06 – 2013/12	217		
2	Pre	2003/07 – 2007/12	317	0.603	19.4%
	Post	2008/01 – 2013/12	227		
3	Pre	2003/07 – 2009/12	340	0.394	19.5%
	Post	2010/01 – 2013/12	203		

A (basis) regression includes LN(age), LN(assets), LN(gross proceeds with overallotment), the dummy venture backed, underwriter's reputation, the number of uses of proceeds, 20 days standard deviation of the returns and the trading volume as the independent variables. This results in the values that can be seen in the last two columns of *Table 4*. Based on the lower probability of those coefficient and the slight higher adjusted R^2 I decide to take period 3 as the definition for pre- and post-crisis.

Figure 1: 3 months moving average number of IPOs

3-months moving average number of IPO conducted in a given year and month for the initial sample of 2102 observations.



3.1.4 Descriptive statistics

In *Table 5* an overview of the sample is given, divided by the pre- and post-crisis period as defined in the previous paragraph. The variables in this table include the continuous (in)dependent variable(s). The average underpricing for the whole sample amounts to 15.2% while for pre-crisis (post-crisis) this number is 13.1% (18.8%). In general, it seems that post-crisis, all the variables have higher values for both mean and median, when comparing those values to pre-crisis. The only exception to this is the mean for age. In section 4.3 an independent t-test of difference will be conducted to test whether certain variables differ significantly from each other to determine if an interaction-effect should be included.

Table 5: Descriptive statistics

This table provides the descriptive statistics for the continuous (in)dependent variable(s) for the sample of 543 IPOs that were issued between July 2007 and December 2013. This sample includes IPOs that were listed at either the NYSE, AMEX or NASDAQ. All variables are shown in percentages. The second and third row of each variable divides the total sample into a pre- and a post-crisis period. Pre-crisis is defined from July 2003 up to and including December 2009 (340 observations) and Post-crisis is defined from January 2010 up to and including December 2013 (203 observations).

Variable	Sample	Mean	Median	Min	Max	Stdev
Underpricing (%)	Whole	15.2	9.8	-91.2	119.8	23.3
	Pre	13.1	8.7	-91.2	97.2	20.4
	Post	18.8	11.9	-22.6	119.8	27.2
Age (yrs)	Whole	13	8	1	158	18
	Pre	14	8	1	158	20
	Post	12	9	1	143	14
Assets ($mln)	Whole	551	69	0.6	137,238	5,964
	Pre	358	65	0.8	12,268	1,203
	Post	878	74	0.6	137,238	9,659
Gross Proceeds ($mln)	Whole	185	83	4	16,007	971
	Pre	128	81	6	1,876	174
	Post	281	86	4	16,007	1,574
20-day standard deviation of return (%)	Whole	14.8	13.4	2.0	50.6	7.3
	Pre	14.0	12.3	2.0	47.9	7.2
	Post	16.3	15.2	2.4	50.6	7.2
First day trading volume scaled by shares issued (%)	Whole	67.5	59.4	0.0	442.9	53.2
	Pre	65.1	56.9	0.0	442.9	53.1
	Post	71.7	63.6	0.2	384.7	53.2

Tables 6 till 9 give the remaining descriptive statistics for the dummy venture backed (*Table 6*), underwriters' reputation *(Table 7*), number of observations in hot or cold months (*Table 8*) and the variables that are used as a proxy for ex post uncertainty are shown in *Table 9*.

Table 6 gives an overview of the distribution whether the IPO was backed by a venture capitalist (dummy). For the whole, as well as for the pre- and post-crisis sample, the majority of the IPO are backed by venture capitalists. When comparing pre- with post-crisis even more IPOs seem to be venture backed post-crisis (82% vs. 65%).

Table 6: Venture backed IPOs

An overview of the dummy venture backed. The dummy takes the value 1 if the IPO was venture backed and the value 0 if it was not. The sample is divided for pre- and post-crisis.

		Yes	No
Venture Backed	Whole	387 (71%)	156 (29%)
	Pre	222 (65%)	119 (35%)
	Post	165 (82%)	37 (18%)

Table 7: Methods for classifying underwriters' reputation

An overview of the underwriters' reputation. Again, the sample is divided by pre- and post-crisis. In addition two other methods of classifying the underwriters' reputation are used. Method 1 is the method described in the theoretical framework, while method 2 and 3 split the sample into a 2-way classification system (low and high). For method 1 the dummy takes the value 1 if the rank is below 5 and zero otherwise. Then, for ranks between 5 and 8 the dummy takes the value 1 and 0 otherwise. A third dummy is constructed that takes the value 1 for ranks above and equal to 8 and 0 otherwise. For method 2 (method 3) the dummy takes the value 1 if the rank is higher or equal to 7 (8) and 0 (0) otherwise.

			Rank < 5	5 =< Rank < 8	Rank >= 8
Underwriters' reputation	Method 1	Whole	28 (5%)	126 (23%)	389 (72%)
		Pre	17 (5%)	84 (25%)	240 (70%)
		Post	11 (5%)	42 (21%)	149 (74%)
			Rank <7	**Rank >= 7**	
	Method 2	Whole	72 (13%)	471 (87%)	
		Pre	52 (15%)	289 (85%)	
		Post	20 (10%)	182 (90%)	
			Rank <8	**Rank >=8**	
	Method 3	Whole	154 (28%)	389 (72%)	
		Pre	101 (30%)	240 (70%)	
		Post	53 (26%)	149 (74%)	

Table 7 gives an overview of the distributions of the underwriters' reputation. For all three methods the distribution of ranks are centred at the high end. Method 1 shows that relatively few observations (5%) for all (sub)samples have a rank that is lower as 5. Considering a two-way classification, method 2 and 3 show that between pre- and post-crisis the underwriter's rank does not seem to show any big differences with up to 5 percentage points difference at most.

Table 8 gives an overview of the amount of observations classified as either hot, cold or neutral. Regardless of the method used (this is explained in section 3.2) the majority of the IPOS are conducted in neutral months. The number of observations classified as neutral range from 65% to 87%. The amount of offerings that are classified in cold months is on the low end ranging from 6% to 10%. Overall it seems that for method 2, between pre- and post-crisis there is no difference for hot, cold or neutral observations. For method 1 it shows that post-crisis the percentage IPOs conducted in hot months are relatively large compared to pre-crisis.

Table 8: Number of Hot/Cold observations

An overview of the number of observations classified as either hot, cold or neutral periods. Hot (Cold) periods are defined where 3 months in a row, the 3 months moving-average number of IPOs conducted is higher (lower) than the top (bottom) quartile of that period 3 months moving-average. The dummy Hot (Cold) takes the value 1 when the month of issue is classified as hot (cold) and 0 otherwise. Months which were classified as neither hot nor cold are neutral months.

			Hot	**Cold**	**Neutral**
Hot/Cold period	Method 1	Whole	68 (13%)	33 (6%)	442 (81%)
		Pre	24 (7%)	20 (6%)	297 (87%)
		Post	44 (22%)	13 (6%)	145 (72%)
	Method 2	Whole	142 (26%)	46 (9%)	355 (65%)
		Pre	82 (24%)	25 (7%)	134 (69%)
		Post	60 (30%)	21 (10%)	127 (60%)

In establishing how to segregate the trading days I follow the approach of Falconieri, Murphy, & Weaver (2009). In their paper they found that the lion part of the trading in the secondary market happens in the first few minutes. When looking at the bid-ask spread they observe a decrease of this spread in the first 4 minutes of trading. However, they also note that not all IPOs trade significant amounts in the first 4 minutes. They therefore separate the day into the first two hours and the remainder of that day, to fully capture the decrease in bid ask spread in the beginning of trading. The same approach is used in this paper.

Table 9: gives an overview of the three different measurements that are used as proxies for ex post uncertainty. One absolute and two relative measures are used. Looking at the sample as a whole the standard deviation of quote midpoints is higher for day 1 than for day 2 (43.2% vs. 26.5%), indicating that the ex post uncertainty, is higher at the first day of trading. Examining the difference between the daily sub periods reveals that the first 2 hours of trading are more uncertain than the remainder of the day (35.8% vs. 24.0%) and (20.6% vs. 18.6%). The same observations hold when looking at the other two measurement of ex post uncertainty.

Looking at the sample divided by pre- and post-crisis it is noteworthy that no matter the (sub)period (day 1 or day 2), the ex post uncertainty is always higher for post-crisis (51.0% vs 38.7%, 39.6% vs 33.5% etc.).

Table 9: ex post uncertainty proxies (part 1/2)

An overview of 3 different measurements that are used as a proxy for ex post uncertainty. I use 1 absolute and 2 relative measures of ex post uncertainty. The (**1**) standard deviation of quote midpoints is used as an absolute measure. The **(2)** standard deviation of quote midpoints *returns* and the **(3)** standard deviation of quote midpoints divided by the offer price are used as relative measures. On this page one absolute and one relative measure are shown. The next page shows the second relative measure. All values are in percentages. For all 3 measurements the sample is divided into the first two trading days of an IPO. Then, every day is divided into three sub-periods: (i) the entire day, (ii) the first 2 hours and (iii) the remainder of that day. In addition, all those periods are divided by the pre- and post-crisis period as defined in paragraph 3.1.3.

Measure	Period		Mean	Median	Min	Max	Stdev.
(1) Standard deviation of quote midpoints (%)	Day 1 - All	Whole	43.2	30.6	1.5	831.3	50.2
		Pre	38.7	27.8	1.5	269.8	35.8
		Post	51.0	35.1	3.1	831.3	67.3
	Day 1 - 1st 2hrs	Whole	35.8	25.8	1.9	247.0	32.3
		Pre	33.5	25.2	1.9	238.7	30.4
		Post	39.6	27.7	3.2	247.0	34.9
	Day 1 - rest	Whole	24.0	15.7	0.4	499.4	32.4
		Pre	20.6	14.4	0.4	255.3	22.9
		Post	29.8	19.3	1.5	499.4	43.5
	Day 2 - All	Whole	26.5	16.9	0.4	279.5	31.6
		Pre	23.9	16.7	0.4	166.0	23.9
		Post	30.9	17.0	0.8	279.5	41.1
	Day 2 - 1st 2hrs	Whole	20.6	13.1	0.2	230.8	22.6
		Pre	19.2	13.1	0.2	129.2	18.8
		Post	23.0	13.8	0.9	230.8	27.8
	Day 2 - rest	Whole	18.6	10.8	0.2	245.1	25.5
		Pre	16.4	10.4	0.2	137.6	19.3
		Post	22.3	11.7	0.2	245.1	33.2
(2) Standard deviation of quote midpoints returns (%)	Day 1 - All	Whole	0.23	0.15	0.01	6.77	0.40
		Pre	0.26	0.16	0.02	6.77	0.48
		Post	0.18	0.13	0.01	1.34	0.20
	Day 1 - 1st 2hrs	Whole	0.24	0.15	0.01	9.14	0.49
		Pre	0.28	0.18	0.02	9.14	0.60
		Post	0.18	0.13	0.01	1.46	0.18
	Day 1 - rest	Whole	0.19	0.12	0.00	3.09	0.27
		Pre	0.20	0.12	0.01	3.09	0.28
		Post	0.18	0.12	0.00	1.9	0.25
	Day 2 - All	Whole	0.35	0.21	0.00	6.2	0.52
		Pre	0.33	0.20	0.01	5.6	0.51
		Post	0.38	0.23	0.00	6.2	0.55
	Day 2 - 1st 2hrs	Whole	0.38	0.20	0.00	10.2	0.76
		Pre	0.38	0.20	0.01	10.2	0.84
		Post	0.39	0.21	0.00	7.1	0.60
	Day 2 - rest	Whole	0.31	0.19	0.00	5.6	0.44
		Pre	0.28	0.18	0.01	4.0	0.37
		Post	0.35	0.20	0.00	5.6	0.54

Table 9: ex post uncertainty proxies (part 2/2)

This table shows the **(3)** standard deviation of quote midpoints divided by the offer price. It is the second relative measure that is used to capture ex post uncertainty. All values are in percentages. This measurement is also divided into the first two trading days of an IPO. Then, every day is divided into three sub-periods: (i) the entire day, (ii) the first 2 hours and (iii) the remainder of that day. In addition, all those periods are divided by the pre- and post-crisis period as defined in paragraph 3.1.3.

Measure	Period		Mean	Median	Min	Max	Stdev.
(3) Standard deviation of quote midpoints divided by the offer price	Day 1 - All	Whole	3.2	2.5	0.1	18.5	2.4
		Pre	2.9	2.3	0.1	15.0	2.2
		Post	3.6	2.9	0.3	18.5	2.7
	Day 1 - 1st 2hrs	Whole	2.7	2.1	0.1	14.6	2.1
		Pre	2.6	2.0	0.1	13.7	2.1
		Post	2.9	2.3	0.3	14.6	2.1
	Day 1 - rest	Whole	1.7	1.3	0.0	12.8	1.5
		Pre	1.5	1.2	0.0	9.8	1.3
		Post	2.0	1.6	0.1	12.8	1.7
	Day 2 - All	Whole	1.9	1.4	0.0	11.2	1.8
		Pre	1.8	1.4	0.0	11.2	1.7
		Post	2.1	1.4	0.1	10.6	2.0
	Day 2 - 1st 2hrs	Whole	1.5	1.1	0.0	9.2	1.3
		Pre	1.5	1.1	0.0	8.4	1.3
		Post	1.6	1.1	0.1	9.2	1.5
	Day 2 - rest	Whole	1.3	0.9	0.0	11.2	1.4
		Pre	1.3	0.9	0.0	9.1	1.3
		Post	1.5	1.0	0.0	11.2	1.6

3.1.5 Variables overview

Table 10 is gives an overview regarding the variables that will be used in the regression.

Table 10: Variables overview

In this table an overview is given of all the variables that will be used in the regression analysis. Column (1) lists the kind of variable, column (2) classifies the variables into ex ante, aftermarket or ex post variables as outlined in paragraph 2.2. Column (3) lists all the variables that will be used in the regression.[15] The final column gives a short description of each variable.

(1) Sort	(2) Classification	(3) Variables as in the regression	(4) Short description
Dependent Variable		UP	Percentage difference between the offer price and the closing price
Independent Continuous Variables	Ex ante Variables	Age	Age of the company in years determined by the founding date
		Assets	Size of the company
		Gross_p	Size of the offering
		Uses_p	How will the invested money be put to use
	Aftermarket variables	20days_stdev	Standard deviation of 20-days aftermarket returns
		Trad_vol	1st day trading volume scaled by total shares issued
	Ex post Variables	stdev_QM	standard deviation of quoted midpoints
		stdev_QMR	standard deviation of quoted midpoints returns
		stdev_QM/OP	standard deviation of quoted midpoints divided by offer price
Independent Categorical Variables	Ex ante Variables	VB_d	Dummy whether the IPO was venture backed
		Rank_low_d	Dummy whether the underwriter's rank is classified as low
		Rank_med_d	Dummy whether the underwriter's rank is classified as medium
		Rank_high_d	Dummy whether the underwriter's rank is classified as high
		Hot_d	Dummy whether the IPO was conducted in a hot month
		Cold_d	Dummy whether the IPO was conducted in a cold month
Control Variables		Crisis_d	Dummy whether the IPO was conducted after the crisis
		Tech_d	Dummy whether the IPO was a tech company
		Biotech_d	Dummy whether the IPO was a biotech company
		Internet_d	Dummy whether the IPO was an internet company

[15] The way certain variables will be interacted with each other is not shown here, but will be highlighted in the empirical part

3.2 Methodology

3.2.1 Regression Model

The following regression is used for assessing what influences the degree of underpricing:

$$Underpricing_i\,(\%) = \beta_0 + \beta_1 LN(1 + Age)_i + \beta_2 LN(Assets)_i + \beta_3 LN(Gross\_proceeds\_with)_i + \beta_4 VB\_d_i + \beta_5 Rank\_high\_d_i + \beta_6 Rank\_low\_d_i + \beta_7 Uses\_p_i + \beta_8 Hot\_d_i + \beta_9 Cold\_d_i + \beta_{10} 20days\_stdev_i + \beta_{11} Trad\_vol_i + \beta_{12} Crisis\_d_i + \beta_{13} Tech\_d_i + \beta_{14} Biotech\_d_i + \beta_{15} Internet\_d_i + \sum_{j=16}^{n} \beta_j\, Proxy_j \qquad (1)$$

Dependent variable

The degree of underpricing is defined as the difference between the offer price (OP) and the first day closing price (CP): (CP-OP)/CP. A positive return indicates that the offering was under-priced, while a negative return indicates that the offering was over-priced

Independent continuous variables

Age is the time in years the company exists. It is constructed by (year of issuance – year of founding). Note that date of issuance and the founding date are not rounded. So a company founded at 01/01/2000 and conducting an IPO at 31/12/2008 is 8 years old, while that company is practically 9 years old. Depending on the outcomes of the regression the *LN(1+age)* might be used as done before by (Loughran & Ritter, 2004).

Assets is used as a proxy for size. The log of total amount of assets before the offering is taken. The log is used to normalize the distribution.

Gross proceeds with is the total size of the offering, including the overallotment option and is calculated by multiplying the offer price times the amount of shares issued. The log is used to normalize the distribution.

The number of uses of the proceeds are specifications on how the invested money will be put to use. These specifications can range from very general (like secondary) to with more detail (like reduce indebtedness). As concerns have been expresses by previous scholars regarding the viability of these uses, I construct one additional variation on this variable. The first one is to take all the uses, while the second variation excludes the uses that are named ‘other’, ‘general corporate purposes’ and ‘secondary’. These uses are deemed too vague.

Std. Dev. of the 20-days aftermarket returns is the average 20-day standard deviation of the return in aftermarket. It is computed by the daily closing prices from the beginning of the IPO to 20 days after the IPO. It is then multiplied by the square root of 21 (average trading days per month) to arrive at a monthly standard deviation.

Trading Volume: Miller and Reilly (1987) found in their sample of 510 IPOs that the ones with an initial underpricing (positive return) had a relative higher trading volume than the IPO with an initial over-pricing (negative return). They scaled the first day trading volume by the amount of issues shared. In this paper the same methodology is applied.

Proxies for ex post uncertainty

Absolute measure: the standard deviation of quote midpoints is calculated by taking the standard deviation of the [(quoted offer price + quoted bid price)/2]. Following the paper of Falconieri, Murphy, & Weaver (2009) the standard deviation first two trading days is calculated. Each day is calculated as a whole and subdivided by the first 2 hours of that day and the remainder of that day.

Relative measure: standard deviation of quote midpoint returns is calculated by taking the standard deviation of the returns of the [(quoted offer price + quoted bid price)/2]. The methodology is the same as for the absolute measure for ex post uncertainty.

Relative measure: standard deviation of quote midpoints divided by the offering price is calculated by taking the standard deviation of {[(quoted offer price + quoted bid price)/2]/Offer price}. This proxy is nothing else than the absolute measure of ex post uncertainty scaled by the offer price.

Independent categorical variables

Venture backed is a dummy that takes the value 1 if the IPO was backed by venture capitalists

The underwriter's reputation is constructed by looking at the relative positions of the underwriters in the tombstone announcement. The higher the position of the underwriter the higher their rank. This methodology was first used by Carter & Manaster (1990) and fine-tuned by Carter, Dark & Singh (1998). Then, Loughran and Ritter (2004) make several small alterations to the methodology used by Carter, Dark & Singh (1998). Moreover, Ritter keeps an updated file available on his webpage regarding those underwriter rankings.[16] Thomsoneone provides the names of the underwriters that are then matched with the rankings by Ritter. If more as 1 underwriter is present I calculate the average ranking of those underwriters. The ranking ranges from 1 (lowest) to 9 (highest). In Falconieri, Murphy, & Weaver (2009) the authors use the underwriters' rank as a continuous variable and initially that methodology is applied in this paper. To complement, 3 other dummy-methods are used. The first method splits the rankings into 3 categories: low for rankings below 5, medium for rankings between 5 and 8 and high for ranking higher or equal to 8. The second method divides the rankings in low for ranks below 7 and high for ranks higher or equal to 7. The final method divides the rankings in low for ranks below 8 and high for ranks higher or equal to 8. *Table 11* gives this overview.

[16] Available on https://site.warrington.ufl.edu/ritter/ipo-data/

Table 11: Underwriters' ranks

Overview of the different methods used to rank the underwriters' reputation.

		Ranking		
		low	**medium**	**high**
Method 1	Dummy	Rank < 5	5 =< Rank < 8	Rank >= 8
Method 2	Dummy	Rank < 7		Rank >= 7
Method 3	Dummy	Rank < 8		Rank >= 8

Hot or cold periods are determined by looking at the initial sample of 2102 observations that Thomsoneone provided me with, since all those observations had the date of the initial offering, I was able to calculate how many IPOs were conducted in a given year and month. Because certain months are subjected to seasonality (Helwege & Liang, 2004), the 3 months moving-average is used to account for this. Then, the sample is then divided into pre- and post-crisis as defined in paragraph 3.1.3. IPOs from July 2003 to December 2009 are pre-crisis and IPOs from January 2010 to December 2013 are post-crisis. Then, for each period the top and bottom quartile are calculated that are shown in *Table 12*. Note that these quartiles are based on the moving-average number of IPOs conducted per given month and year.

Hot (cold) months are then defined when for 3 months in a row the moving average number of IPOs in a month is higher (lower) as the (bottom) top quartile for that period.

Based on this definition, method 1 in *Table 13* lists the months that are classified as hot or cold. In addition a second method is used to broaden my initial classification of hot and cold months by adding 2 (3) months prior and after the initially classified hot (cold) months. In the final sample of 534 observations, IPOs issued in hot months are assigned the dummy 1 and zero otherwise and IPOs issued in cold months are assigned the dummy 1 and zero otherwise.

Table 12: Moving average number of IPOs

Top and bottom quartile number of IPOs conducted, based on a 3 months moving average to account for seasonality.

		pre	post
Moving average number of IPOs	top quartile	24	19
	bottom quartile	15	13

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Table 13: Hot/Cold months

Overview of years and months classified as hot or cold. Years and months **not** listed in this table are classified as neutral. This classification is based on the initial, uncleaned sample of 2102 observations. It should be noted that the cold period from 2008-04 to 2010-04 is actually an uninterrupted period, as the period from 2008-08 to 2009-was omitted as explained in section 3.1.3. Method 1 applies the methodology as explained in *Table 12*. Method 2 adds 2 (3) months prior and after the initially determined period for hot (cold) months.

		year	months	Total months	Additional months
Hot months	Method 1	2005	9 - 10	2	
		2007	7 - 8	2	
		2013	7 - 12	6	
	Method 2	2005	7 - 12	6	+4
		2007	5 - 10	6	+4
		2013	5 - 12	8	+2
Cold months	Method 1	2008	4 - 7	4	
		2009	6 - 12	7	
		2010	1 - 4	4	
	Method 2	2008	1 - 7	7	+3
		2009	6 - 12	7	+0
		2010	1 - 7	7	+3

Control variables

Crisis_d is a dummy variable that takes the value 1 if the IPO is conducted from 2010-01 onwards and zero otherwise

Tech_d is a dummy that takes the value 1 if the company is classified as a tech-company and zero otherwise.[17]

Biotech_d is a dummy that takes the value 1 if the company is classified as a biotech-company and zero otherwise. [18]

Internet_d is a dummy that takes the value 1 if the company is classified as an internet company and zero otherwise[19]

Table 14 gives the overview of the number of observations defined as either tech, biotech or internet companies. The final row 'Tech or Internet' is added since out of the 77 observations that were classified as internet companies, 62 of those were also classified as tech companies. In that case only 15 'pure' internet companies are defined, which is too few. Therefore I aggregate whether a company is classified as either tech or classified as an internet company.

Table 14: (Bio)Tech classification

Overview of the number of companies that are classified as either tech, biotech, internet companies or tech/internet (dummy takes value 1).

		Dummy value	
		1	**0**
Tech	Whole	239 (44%)	304 (56%)
	Pre	144 (43%)	192 (57%)
	Post	95 (46%)	112 (54%)
BioTech	Whole	128 (24%)	415 (76%)
	Pre	72 (21%)	264 (79%)
	Post	56 (27%)	151 (73%)
Internet	Whole	77 (14%)	466 (86%)
	Pre	43 (13%)	293 (87%)
	Post	34 (16%)	173 (84%)
Tech or Internet	Whole	254 (47%)	289 (53%)
	Pre	155 (46%)	181 (54%)
	Post	99 (48%)	108 (52%)

[17] Tech companies are classified as tech by the following SIC-codes: 3559, 3571, 3572, 3575, 3576, 3577, 3578, 3661, 3663, 3669, 3671, 3672,3674, 3675, 3677, 3678, 3679, 3812, 3823, 3825, 3826, 3827, 3829, 3841, 3845, 4812, 4813, 4899, 7371, 7372, 7373, 7374, 7375, 7378, 7379, 7389

[18] Biotech companies are classified as tech by the following SIC-codes 2830, 2833, 2834, 2835, 2836, 8731

[19] A list of internet IPOs is available on Ritter's website: https://site.warrington.ufl.edu/ritter/ipo-data/

4. Empirical results

In this part several regressions will be used to assess the degree of underpricing. In part 4.1 I explain how the basic regression is constructed and what criteria play a role here. Then, in section 4.2 the basic regression is tested for multicollinearity based on a correlation-matrix and the variance inflation factors. Also a Breusch-Pagan test is conducted to test for heteroscedasticity. In section 4.3 I determine what variables should interact with the crisis dummy based on a Levene's test and a t-test of difference. Part 4.4 discuss the regression results, with and without the proxies for ex post uncertainty.

4.1 Determining the basic regression

The basic regression does **not** include the proxies for ex post uncertainty, denoted in regression (1) by $Proxy_j$. To determine the basic regression a multitude of regression (1) below, without $Proxy_j$, is constructed. To recall, the variable 'rank' for instance has three different methods to be constructed. Similar, the hot period is constructed in two different ways.

$$Underpricing_i\ (\%) = \beta_0 + \beta_1 LN(1 + Age)_i + \beta_2 LN(Assets)_i + \beta_3 LN(Gross\_proceeds\_with)_i + \beta_4 VB\_d_i + \beta_5 Rank\_high\_d_i + \beta_6 Rank\_low\_d_i + \beta_7 Uses\_p_i + \beta_8 Hot\_d_i + \beta_9 Cold\_d_i + \beta_{10} 20days\_stdev_i + \beta_{11} Trad\_vol_i + \beta_{12} Crisis\_d_i + \beta_{13} Tech\_d_i + \beta_{14} Biotech\_d_i + \beta_{15} Internet\_d_i + \sum_{j=16}^{n} \beta_j\ Proxy_j \quad (1)$$

The criteria important for determining the basic regression were the p-value of the coefficients and the adjusted R-squared. The basis regression is given below. The dummies (β_5, β_7, β_8 and β_{11}) all contain a number in their corresponding variable. These numbers are in line with the methodology explained in *Table 11* for β_5 (rank), *Table 12* for β_7, β_8 (hot/cold-period) and *Table 4* for β_{11} (crisis)

$$Underpricing_i\ (\%) = \beta_0 + \beta_1 LN(1 + Age)_i + \beta_2 LN(Assets)_i + \beta_3 LN(Gross\_proceeds\_with)_i + \beta_4 VB\_d_i + \beta_5 Rank\_high2\_d_i + \beta_6 Uses\_p_i + \beta_7 Hot2\_d_i + \beta_8 Cold1\_d_i + \beta_9 20days\_stdev_i + \beta_{10} Trad\_vol_i + \beta_{11} Crisis3\_d_i + \beta_{12} Biotech\_d_i + \beta_{13} Tech\_or\_Inet\_d_i \quad (2)$$

4.2 Multicollinearity and heteroscedasticity

To test for multicollinearity a correlation-matrix and a variance inflation factor are determined. Appendix 6.1 lists the correlation matrix for the basic regression. As no absolute value is higher than 0.800 I claim that, there is no problem with multicollinearity. The variance inflation factors (VIF) tells us the extent to which the standard errors of the coefficient of interest has been inflated upwards. As a rule of thumb a VIF higher or equal to 4 indicate a multicollinearity problem. Appendix 6.2 gives this overview. As the highest value is 2.890 no problem exists. A Breusch-Pagan test is conducted to test for heteroscedasticity, since the P-value is 0.000 (Appendix 6.3), heteroscedasticity is present and in Stata this is solved with the command "robust".

4.3 Crisis interaction

To determine which variables seem to be most logically to interact with the crisis dummy I have a look at the descriptive statistics of the variables in *Table 5, Table 6* and *Table 9.*

Table 5 list the descriptive statistics of the variables used in the basic regression. Looking at median of each variable, separated for pre- and post-crisis, the 20 day stdev. of the return and the first day trading volume scaled by shares issued seem to be different from each other. *Table 6* gives an overview whether the IPO was venture backed. It seems that post-crisis more IPOs seem to be venture backed (82% vs. 65%) *Table 9* lists the proxies for ex post uncertainty. In general, looking at the mean of the first and third proxy, it seems that post-crisis all variables seem to have a higher standard deviation in terms of percentage compared to pre-crisis.

Based on these descriptive statistics and to get a better idea which variables to interact, a t-test is performed for the variables mention in *Table 5, Table 6* and *Table 9.* I use the "two sample t significance test". To assess the equality of variances for pre- and post-crisis a Levene's test is conducted. Appendix 6.4 gives an overview of the Levene's test whether the variances are equal and Appendix 6.5 gives an overview whether the variables pre- and post-crisis differ significantly from each other, based on a t-test of difference. *Table 15* below gives the summary of the variables that will be interacted with the crisis dummy.

Table 15: crisis dummy interaction variables

Overview which variables will interact with the crisis dummy variable. The test-results to arrive at these variables can be found in appendix 6.4 and 6.5. Variables numbered 1 – 2 are the basis regression variables. Variables 3 – 11 are the proxies for the ex post uncertainty.

Variable
1. Venture_backed_d
2. 20days_stdev
3. all_stdev_qm1
4. all_stdev_qmr1
5. all_stdev_qm_op1
6. 2hrs_stdev_qm1
7. 2hrs_stdev_qmr1
8. rest_stdev_qm1
9. rest_stdev_qm_op1
10. all_stdev_qm2
11. rest_stdev_qm2

4.4 Cross-sectional regression

To save space the following abbreviations will be used in this section:

- QM = Quoted midpoint (absolute measure)
- QMR = Quoted midpoint returns (relative measure)
- QM/OP = Quoted midpoints divided by Offer Price (relative measure)

In *Table 16* the regression results are given. **Model 1** is the basis regression that does not include the proxies for ex post uncertainty. **Models 2 – 5** are Model 1 with the stdev. of the QM, **Model 6** is Model 1 with the stdev. of QMR and **Models 7 – 10** are Model 1 with the stdev. of QM/OP.

Model 6 lists the regression for the stdev. of the QMR. None of the regressions, that included this proxy for ex post uncertainty, had significant coefficients and in addition the R^2 only increased to 23.3% compared to 23.0% for **Model 1**. Therefore, I list this model for completeness but it is not further discussed as it does not provide any additional explanatory power or significant coefficients.

Every regression is tested for multicollinearity by calculating the Variance Inflation Factors (VIFs), those can be found in Appendix 6.6. As the highest VIF is lower as 4.0 I see no problem with multicollinearity in any of the models.

Model 1 lists the basic regression without any of the proxies for ex post uncertainty. Age (although insignificant), Gross proceeds and whether the IPO was venture backed have signs which were contrary to what was hypothesized. The remaining variables have signs in line with the hypotheses. The dummy venture backed tells us that on average those IPO have 7.7% more underpricing. Hamao, Packer, & Ritter (2000) also find that venture backed IPO increases underpricing instead of reducing it but they provide no reason for this. I want to highlight the 20 day stdev. with the crisis dummy. *Table 5* lists the descriptive statistics and one standard deviation of the 20 day stdev. leads to 2.63% more underpricing in the whole sample, while after crisis the additional effect increases by 3.48%. Remarkable is that biotech firms seem to enjoy 9.3% *less* underpricing compared to firms that are not. The independent variables explain 23.0% of the underpricing.

Comparing models within models 2 – 5 (QM)

Models 2 – 5 list the basic regression with the absolute measure of ex post uncertainty for different (sub)periods, for the stdev. of Quoted Midpoints (QM). Noteworthy is for all models the trading volume and the 20 day stdev. become insignificant compared to the basic model. As with Model 1 it seems that biotech firms seem to have up to 8.5% *less* underpricing. The coefficients for the dummy venture backed is contrary to the expectation, positive, which leads to up to 6.3% *more* underpricing.

Turning to measure for ex post uncertainty, overall the coefficients have the expected sign and are significant. **Model 2** includes the 1st day of the stdev of QM and the R^2 increases to 34.9% compared to 23.0% for the basic model. **Model 3**, then disaggregates the 1st day into the first two hours and the remainder of that day and this increases the R^2 to 41.7%. **Model 4**, then disaggregates the 1st day into the first two hours and the remainder of that day and includes the 2nd day stdev. of QM, this increases the R^2 to 45.4%. **Model 5** then disaggregates both the 1st and the 2nd day but this doesn't lead to more predictive power. It seems that, based on the increase of the R^2 by 15 percentage points when going from model 1 to model 2, the underpricing seems to be largely explained by the ex post uncertainty that exists on day 1. It is worth mentioning that the R^2 increases with every model, but going from model 4 to model 5 only increases the R^2 by 0.8 percentage points, indicating segregating the 2nd trading day into the first two hours and the remainder of that day does not account for a large difference. Ex post uncertainty seems to be the highest during the first trading day of the IPO

In line with *Table 15* I include crisis interaction and show that for **Models 2 and 3** these coefficients are significant when interacted with the entire 1st day and with the first two hours of the 1st day. After-crisis, the stdev. seem to be more severe, resulting in a higher degree of underpricing. This effect in non-existent when disaggregating for the 2nd day.

Comparing models within models 7 – 10 (QM/OP)

Models 7 – 10 list the basic regression with the relative measure of ex post uncertainty for different (sub)periods, for the stdev. of Quoted Midpoints divided by the Offer Price (QM/OP). Noteworthy is for all models the trading volume becomes insignificant compared to the basic model. As with Model 1 it seems that biotech firms seem to have up to 8.4% *less* underpricing. The coefficients for the dummy venture backed is contrary to the expectation, positive, which leads to up to 6.1% *more* underpricing.

Turning to measure for ex post uncertainty, all the coefficients have the expected sign and are highly significant. **Model 7** includes the 1st day of the stdev of QM/OP and the R^2 increases to 35.8% compared to 23.0% for the basic model. **Model 8**, then disaggregates the 1st day into the first two hours and the remainder of that day and this increases the R^2 to 41.0%. **Model 9**, then disaggregates the 1st day into the first two hours and the remainder of that day and includes the 2nd day stdev. of QM, this increases the R^2 to 44.6%. **Model 10** then disaggregates both the 1st and the 2nd day but this does not lead to more predictive power. It seems that the ex post uncertainty is mostly resolved after the 1st day of trading on the secondary market.

In line with *Table 15* I include the crisis interaction and show that for **Models 7 and 8** these coefficients are significant when interacted with the entire 1st day. After-crisis, the stdev. seem to be more severe, resulting in a higher degree of underpricing. This effect is also present when disaggregating the 1st day into the first two hours and the remainder of that day. Although the coefficients are greater when segregating the first day compared when taking the whole first trading day (4.001 vs. 5.389), taking one standard deviation from the corresponding variables (*Table 9*), leads to 10.8% vs. 9.16% additional underpricing.

Comparing models 2 – 5 (QM) to models 7 -10 (QM/OP)

Comparing these models make sense as **Models 2 – 5** represent the basis regression with the *absolute* measure for ex post uncertainty, namely the stdev. of the QM, while **Models 7 – 10** represent the basis regression with the *relative* measure of ex post uncertainty, namely the stdev. of the QM/OP.

To be more specific, **Model 2 (7)** include the 1st day stdev. of QM (QM/OP).

Model 3 (8) disaggregate the 1st day stdev. of QM (QM/OP) into the 1st 2 hours and the remainder of that day

Model 4 (9) disaggregate the 1st day stdev. of QM (QM/OP) into the 1st 2 hours and the remainder of the day and includes the 2nd day stdev. Of QM (QM/OP)

Model 5 (10) disaggregate the 1st and 2nd day stdev. of QM (QM/OP) into the 1st 2 hours and the remainder of those day.

While for **Models 2 – 5** the LN(Gross proceeds) becomes insignificant, this is not the case for **Models 7 – 10** where LN(Gross proceeds) stays significant at the 1% level, although with a sign contrary to what was hypothesized. With one exception, the dummy for hot periods are not significant, but with the expected sign (positive). I believe that these non-significant coefficients are the results of too few observations for the hot-period as can be found in *Table 8.* The dummy whether the company was a biotech firm is highly significant with a negative coefficient for all models with a range between 7.1% and 8.5%, indicating that biotech firms have a lower degree of underpricing to up to 8.5% The dummy whether the company was backed by a venture capitalist also highly significant for all models with a positive coefficient for all models with a range between 4.1% and 6.3%. The 20-day stdev. of the after market return becomes insignificant for **Models 2 – 5** when including the proxies for ex post uncertainty, while for **Models 9 -10** this variable stays significant at the 10% benchmark.

Turning to the R^2, **Model 2 (7)** has 34.9% (35.8%) explanatory power, **Model 3 (8)** 41.7% (41.0%), **Model 4 (9)** 45.4% (44.6%) **Model 5 (10)** 45.6% (45.0%). So, comparing <u>different</u> proxies for ex post uncertainty (absolute vs. relative) for the <u>same</u> (sub)periods does not lead to more explanatory power. This is in sharp contrast to the paper of Falconieri, Murphy, & Weaver (2009), who find that using a relative proxy **(Models 7 – 10** in this paper) led to a better fit of the model. However, the finding that the R^2 increases going from the basic model (23.0%) to either **Model 2** (34.9%) or **Model 7** (35.8%) is similar to that of Falconieri, Murphy, & Weaver (2009). Disaggregating the first trading day into the first two hours and the remainder increases the R^2 even more and indicates that ex post uncertainty is more severe during the first two hours of the first trading day. The final noteworthy increase in R^2 is when the second trading day is added as a whole (so no segregation). Although the R^2 does not increase as much as before, there still exists some uncertainty on the second day as a whole.

When including the crisis dummy with certain ex post uncertainty sub(periods), as reasoned in section 4.3 (*Table 15*), the majority of these interaction coefficients were highly significant and with the anticipated sign (positive). For **Models 2 – 5** exceptions were present in the case the crisis dummy was interacted with the remainder of the first or second day. For **Models 7 – 10** all the coefficients were significant at the 1% level. To give some sort of idea to what degree the crisis dummy effect this underpricing I use one standard deviation from *Table 9* (part 2/2) for the crisis interaction between the whole first day (**Model 7)**. The additional underpricing for IPOs conducted after the crisis using this proxy is 10.7%. Similar, disaggregating the 1st day into the first two hours and the remainder of that day **(Model 8)** leads to a higher degree of underpricing by 9.1% when interaction with the crisis dummy is included. It seems that IPOs conducted after the crisis seem to have an additional larger effect on the initial underpricing, that is caused by an apparent higher standard deviation of the quoted midpoints or its relative counterpart, the quoted midpoints scaled by the offer price.

Overall, the results provide evidence that uncertainty regarding the true value of the shares of an IPO is not resolved once the IPO starts trading. Apart from ex ante variables to explain the persistent underpricing for IPOs, additional explanatory power can be obtained from including ex post uncertainty proxies. When including those proxies the R^2 almost doubles with highly significant coefficients. These findings are in line with the theory of (Draho, 2001) and Chen & Wilhelm (2008) and the results of Falconieri, Murphy, & Weaver (2009). Supplementing existing literature I include a dummy for IPOs that are conducted after the crisis and conclude that more ex post uncertainty exists for post-crisis IPOs resulting in a higher initial return.

Table 16: Regression results (part 1/3)

In this table the initial underpricing is set out against a number of independent variables. The total sample consist of 543 IPOs for all models that were conducted between July 2003 and December 2013. A crisis dummy is included for IPOs conducted after December 2009. This results in 340 IPOs conducted pre-crisis and 203 IPOs conducted post-crisis. All IPOs were listed on either the NYSE, NASDAQ or AMEX. Model 1 shows the basic regression. There are three different proxies for ex post uncertainty, one absolute proxy and two relative measures. Models 2 – 5 list the absolute measure, which is the stdev. of the Quoted Midpoints. Model 6 list the first relative measure, which is the stdev. of the Quoted Midpoints Returns. Models 7 – 10 list the second relative measure, which is the stdev of the Quoted Midpoints divided by the Offer Price. All the proxies are measured over the first two trading days of the IPO. Each day is also segregated by the first two hours and the remainder of that day. *Underpricing* is measured by the percentage difference between the offer price and the first day closing price. *LN(1+age)* is the log of one plus the age of the firm. *LN(Assets)* is the log of the firm's assets. *LN(Grossp w/)* is the log of the firm's offering size including the overallotment option. *Rank_high2_d* is a dummy variable taking the value 1 for firms where the average underwriter rank was above 7. *Uses_p* denotes the number of uses listed in the prospectus. *Hot2_d (Cold1_d)* is a dummy variable indicating a hot (cold) observation for which the IPO was classified in a hot (cold) period. *Trad_vol* indicates the amount of shares traded on the first trading day scaled by total shares issued. *Biotech_d* indicates a dummy variable whether a firm is classified as biotech. *Tech_or_inet_d* is a dummy variable and takes the value 1 when classified as a tech or an internet company. *Vb_d* indicates whether an IPO was backed by venture capitalists. *20days_stdev* denotes the monthly average 20 day standard deviation of the aftermarket. The p-values are between parentheses. The final row contains the adjusted R^2 for each model.

		Basic	**Stdev. Quoted Midpoints**				**Std. QMR**	**Stdev. Quoted Midpoints divided by Offer Price**			
Expected sign	**Variable**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Intercept	-0.781**	-0.386	-0.104	0.009	0.068	-0.846**	-0.818***	-0.734**	-0.704**	-0.711**
		(0.018)	(0.159)	(0.701)	(0.971)	(0.791)	(0.016)	(0.006)	(0.011)	(0.011)	(0.010)
-	LN(1+age)	0.001	-0.001	-0.003	0.002	0.002	0.000	-0.004	-0.007	-0.001	-0.001
		(0.948)	(0.938)	(0.802)	(0.815)	(0.841)	(0.992)	(0.739)	(0.522)	(0.900)	(0.961)
-	LN(Assets)	-0.029***	-0.020**	-0.017**	-0.017**	-0.015**	-0.028***	-0.021***	-0.018**	-0.018**	-0.017**
		(0.001)	(0.014)	0.027)	(0.027)	(0.040)	(0.002)	(0.009)	(0.017)	(0.017)	(0.020)
-	LN(Grossp w/)	0.071***	0.040**	0.022	0.015	0.010	0.074***	0.063***	0.057***	0.053***	0.052***
		(0.001)	(0.022)	(0.186)	(0.329)	(0.523)	(0.001)	(0.000)	(0.001)	(0.001)	(0.002)
-	Rank_high2_d	-0.029	-0.003	0.002	0.011	0.008	-0.029	-0.004	-0.004	0.010	0.007
		(0.294)	(0.903)	(0.927)	(0.557)	(0.677)	(0.267)	(0.869)	(0.849)	(0.633)	(0.725)
+	Uses_p	0.002	0.000	-0.002	-0.003	-0.003	0.003	-0.001	-0.003	-0.002	-0.002
		(0.660)	(0.985)	(0.656)	(0.548)	(0.594)	(0.649)	(0.871)	(0.580)	(0.653)	(0.691)
+	Hot2_d	0.040	0.036	0.024	0.015	0.017	0.038	0.035	0.036*	0.029	0.030
		(0.109)	(0.117)	(0.256)	(0.454)	(0.393)	(0.124)	(0.123)	(0.099)	(0.160)	(0.138)
-	Cold1_d	-0.035	-0.005	0.004	0.011	0.012	-0.039*	-0.005	-0.002	0.005	0.004
		(0.137)	(0.835)	(0.858)	(0.638)	(0.610)	(0.099)	(0.809)	(0.942)	(0.810)	(0.854)

Table 16: Regression results (part 2/3)

Expected sign	Variable	Basic 1	Stdev. Quoted Midpoints 2	3	4	5	Std. QMR 6	Stdev. Quoted Midpoints divided by Offer Price 7	8	9	10
+	Trad_vol	0.111**	0.038	0.023	0.014	0.017	0.113**	0.068	0.065	0.060	0.062
		(0.024)	(0.410)	(0.609)	(0.746)	(0.699)	(0.026)	(0.128)	(0.138)	(0.166)	(0.156)
	Biotech_d	-0.093***	-0.085***	-0.083***	-0.076***	-0.074***	-0.092***	-0.084***	-0.082***	-0.073***	-0.071***
		(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.005)
	Tech_or_inet_d	-0.026	-0.026	-0.035	-0.028	-0.028	-0.024	-0.032	-0.036	-0.030	-0.029
		(0.351)	(0.307)	(0.140)	(0.226)	(0.223)	(0.388)	(0.204)	(0.142)	(0.218)	(0.229)
-	vb_d	0.077***	0.063***	0.051**	0.045**	0.041**	0.080***	0.061***	0.057***	0.051***	0.046**
		(0.001)	(0.004)	(0.011)	(0.021)	(0.034)	(0.001)	(0.003)	(0.003)	(0.008)	(0.015)
+	20days_stdev	0.361***	0.106	0.122	-0.016	-0.018	0.367***	0.109	-0.028	-0.236*	-0.225*
		(0.005)	(0.404)	(0.323)	(0.903)	(0.888)	(0.007)	(0.424)	(0.829)	(0.079)	(0.087)
	20days_stdev*crisis3_d	0.484***	0.366**	0.100	0.013	0.005	0.422**	0.142	-0.009	-0.135	-0.128
		(0.001)	(0.028)	(0.494)	(0.923)	(0.968)	(0.027)	(0.291)	(0.951)	(0.354)	(0.383)
Stdev. Quoted Midpoints (QM)	1st all QM		0.241***								
			(0.000)								
	1st all QM*crisis3_d		0.167***								
			(0.005)								
	1st 2hrs QM			0.213***	0.181***	0.177***					
				(0.000)	(0.001)	(0.001)					
	1st 2hrs QM*crisis3_d			0.360***	0.300***	0.305***					
				(0.000)	(0.000)	(0.000)					
	1st rest QM			0.234**	0.177*	0.136					
				(0.013)	(0.062)	(0.165)					
	1st rest QM*crisis3_d			0.094	-0.002	0.012					
				(0.169)	(0.979)	(0.872)					
	2nd all QM				0.176***						
					(0.001)						
	2nd all QM*crisis3_d				0.221***						
					(0.000)						
	2nd 2hrs QM					0.217***					
						(0.006)					
	2nd rest QM					0.095					
						(0.125)					
	2nd rest QM*crisis3_d					0.087					
						(0.447)					

Table 16: Regression results (part 3/3)

		Basic	Stdev. Quoted Midpoints				Std. QMR	Stdev. Quoted Midpoints divided by Offer Price			
	Variable	1	2	3	4	5	6	7	8	9	10
Stdev. Quoted Midpoints Returns (QMR)	1st 2hrs QMR						-0.231				
							(0.835)				
	1st 2hrs QMR*crisis3_d						5.955				
							(0.462)				
	1st rest QMR						2.747				
							(0.219)				
	2nd 2hrs QMR						-1.184**				
							(0.016)				
	2nd rest QMR						0.163				
							(0.912)				
Stdev. Quoted Midpoints divided by Offer Price (QM/OP)	1st all QM/OP							3.760***			
								(0.000)			
	1st all QM/OP*crisis3_d							4.001***			
								(0.000)			
	1st 2hrs QM/OP								2.764***	2.154***	2.275***
									(0.000)	(0.000)	(0.000)
	1st rest QM/OP								4.802***	3.932***	3.450***
									(0.000)	(0.000)	(0.002)
	1st rest QM/OP*crisis3_d								5.389***	4.013***	3.570**
									(0.000)	(0.004)	(0.013)
	2nd all QM/OP									3.125***	
										(0.000)	
	2nd 2hrs QM/OP										3.130***
											(0.000)
	2nd rest QM/OP										1.859**
											(0.048)
	Adj. R^2	23.0%	34.9%	41.7%	45.4%	45.6%	23.3%	35.8%	41.0%	44.6%	45.0%

***, **, * Significance the 0.01, 0.05 and 0.1 level

5. Conclusion and Implications

This paper looked into the persisting underpricing that exists in Initial Public Offerings (IPOs). Heaps of research has been done regarding proxies for ex ante value uncertainty and those proxies have been confirmed by numerous empirical literature. It was only relatively recent that scholars started to consider the ex post value uncertainty, or the value uncertainty that exists after the IPO has been conducted.

Underpricing exists when the first day closing price is *above* the offer price. It can be debated whether the offer price is too *low,* or the first day closing price is too high. Accepting the closing price as a given, the starting point is that the offer price is too low. Chen & Wilhelm (2008) argue that the time-frame in which IPOs are priced is too narrow, and potentially important information still has to find its way into the market, after the IPO has already been conducted. Draho (2001) stresses that underpricing occurs when there is uncertainty over the secondary market price and argues that the quality and quantity of the information produced in the primary market has to increase in order to eliminate this uncertainty in the secondary market.

Together these two papers suggest that uncertainty exists after the IPO has been conducted. In Saar (2001) the author links the bid-ask spread with this uncertainty and three proxies for ex post uncertainty, set out by Falconieri, Murphy, & Weaver (2009), are used to capture this uncertainty. This paper contributes to existing literature in several ways: (i) provide evidence for the established ex ante variables, (ii) confirming the ex post uncertainty proxies set out by recent literature and (iii) testing whether the global financial crisis of 07/08 has any additional effect on the degree of underpricing.

Three proxies are used: 1) the standard deviation of quoted midpoints, 2) the standard deviation of quoted midpoints returns and 3) the standard deviation of the quoted midpoints divided by the offer price. Proxies 2) and 3) are relative measures, while proxy 1) is an absolute measure. For all proxies the first and second day of trading are segregated into the first two hours and the remainder of that day. In addition the crisis dummy variable is interacted with pre-selected variables to test for any potential additional effect.

The findings concerning the coefficients of the well-established ex ante variables are in line with most of the hypotheses and the basic model that only included ex ante variables explained 23% of the variation in underpricing. Turning to the models where the first and third proxy for ex post uncertainty were included, almost led to a doubling of the explanatory power. Without segregating the trading day, for the absolute proxy the R^2 increased to 34.9%, while for the relative proxy the R^2 increased to 35.8%. While Falconieri, Murphy, & Weaver (2009) found an 8 percentage point increase in explanatory power when including the relative measure for ex post uncertainty, this was not found in this paper.

Segregating the first trading day into the first two hours and the remainder of that day even led to a higher fit of the model of up to 41.7%for the absolute proxy and 41.0% for the relative proxy. This indicates that higher volatility exists during the beginning of the first day and diminishes thereafter. This implicates that the first two hours of the first trading day are more uncertain as suggested by Falconieri, Murphy, & Weaver (2009). Segregating the second day did not have that effect. Noteworthy is that for the absolute measure for ex post uncertainty nearly all coefficients were significant with the anticipated sign (positive). For the relative measure for ex post uncertainty the results are even more impressing as *all* (no exception) coefficients were significant at the 5% level with the anticipated sign (positive). Even though the R^2 was similar when comparing the same models for different proxies (absolute vs. relative), the models which included the relative proxy for ex post uncertainty had more significant coefficients.

No additional explanatory power was found when including the second proxy for ex post uncertainty: the standard deviation of the quoted midpoint returns.

The results provide evidence for the existence for ex post uncertainty and confirm the proxies developed by Falconieri, Murphy, & Weaver. It seems that uncertainty remains after the IPO has been conducted. Following the theory of Chen and Wilhelm (2008) this indicates that the time-frame of bookbuilding is too short and new information triggered by the bookbuilding process still has to be processed. This could implicate that bookbuilding as is, has to be revised to allow for all the information to be correctly incorporated to arrive at a more precise value of the IPO. Following the theory of Draho (2001), the results indicate that there is uncertainty in the secondary market about the IPO's true value that stems from too few information in the primary market. This implicates that other IPO mechanisms where the quality and quantity of the produced information has to increase in the primary market to migitate the degree of underpricing.

The crisis interaction dummy was included for IPOs conducted after December 2009. To determine which variables would interact a t-test of difference was used to compare pre- and post-crisis and an interaction was used accordingly. Looking at the absolute measure of ex post uncertainty the crisis dummy had a significant effect when segregating the first day into the first two hours. Using one standard deviation from the corresponding variable led to an additional underpricing of up to 13% post-crisis. Looking at the relative measure of ex post uncertainty, the severity of the underpricing was somewhat lower with an additional underpricing of up to 9%. It seems that, regardless whether the proxy was classified as absolute or relative, IPOs conducted after the crisis seem to contain more ex post uncertainty leading to a higher degree of underpricing. This could indicate that the market participants seem to believe that there is more uncertainty regarding IPOs conducted after December 2009, resulting in higher initial return demanded to be compensated for this uncertainty.

It is worth looking into why firms classified as biotech seem to have a consistent lower degree of underpricing of up to 9.3%. This was observed for all ten regression models. The proxies for ex post uncertainty were all (indirectly) obtained from the Trade and Quote (TAQ) database. This database lists 13 exchanges on which the quotes could have been listed. To see whether it makes any difference in standard deviation which exchange is used to arrive at those proxies, a comparison of those different stock exchanges should be examined. Moreover, a great deal of IPOs do not seem to start trading at 09:30 am, which is when the US markets open, but start trading at 11:00 or even after noon. TAQ does not provide any information on why this occurs. Is this delayed trading the results because the IPO does not adhere to all the rules outlined by the SEC, or is there some other reason that in turn might have influenced the results. Furthermore, some exchanges in particular quote insanely high bid or offer prices that take values of 20,000 (which were excluded). As no reason was found for this it might be interesting to find out why these high quotes occur. As a final remark further research could also concern the behavioral explanations to explain underpricing, as this is still in its infancy. This is viable option considering that not all the variation in underpricing is explained by the independent variables.

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6. Appendices

Appendix 6.1

Basic regression correlation matrix for the independent continuous variables.

	LN(1+age)	LN(Assets)	LN(Grossp w/)	Uses_p	20days_stdev	Trading volume
LN(1+age)	1					
LN(Assets)	0.321	1				
LN(Grossp w/)	0.214	0.749	1			
Uses_p	-0.161	-0.232	-0.173	1		
20days_stdev	-0.203	-0.267	-0.145	0.195	1	
Trading volume	0.048	0.242	0.361	0.038	0.100	1

Appendix 6.2

Basis regression variance inflation factors and the mean VIF.

Variable	VIF
LN(1+age)	1.2
LN(Assets)	2.9
LN(Grossp w/)	2.7
Venture_backed_d	1.8
Rank_high2_d	1.4
Uses_p	1.2
Hot2_d	1.1
Cold1_d	1.1
20days_stdev	1.2
Trad_vol	1.3
Crisis3_d	1.1
Biotech_d	2.3
Tech_or_inet_d	2.2
Mean VIF	**1.64**

Appendix 6.3

Breusch-Pagan test for heteroscedasticity	
Chi	366.61
Probability	0.000

Appendix 6.4

Levene's test for equality of variances. The p-values are benchmarked against a significance value of 0.05.

Levene's test for variances		
Variable	**P-value**	**Conclusion**
LN(1+age)	0.010	Unequal variances
LN(Assets)	0.300	Equal variances
LN(Grossp w/)	0.198	Equal variances
Venture_backed_d	0.000	Unequal variances
Rank_high2_d	0.000	Unequal variances
Uses_p	0.270	Equal variances
Hot2_d	0.007	Unequal variances
Cold1_d	0.219	Equal variances
20days_stdev	0.743	Equal variances
Trad_vol	0.174	Equal variances
Biotech_d	0.001	Unequal variances
Tech_or_inet_d	0.357	Equal variances
all_stdev_qm1	0.031	Unequal variances
all_stdev_qmr1	0.075	Equal variances
all_stdev_qm_op1	0.009	Unequal variances
2hrs_stdev_qm1	0.004	Unequal variances
2hrs_stdev_qmr1	0.048	Unequal variances
2hrs_stdev_qm_op1	0.509	Equal variances
rest_stdev_qm1	0.000	Unequal variances
rest_stdev_qmr1	0.700	Equal variances
rest_stdev_qm_op1	0.004	Unequal variances
all_stdev_qm2	0.000	Unequal variances
all_stdev_qmr2	0.176	Equal variances
all_stdev_qm_op2	0.011	Unequal variances
2hrs_stdev_qm2	0.000	Unequal variances
2hrs_stdev_qmr2	0.971	Equal variances
2hrs_stdev_qm_op2	0.022	Unequal variances
rest_stdev_qm2	0.000	Unequal variances
rest_stdev_qmr2	0.007	Unequal variances
rest_stdev_qm_op2	0.033	Unequal variances

Appendix 6.5

The two sample t significance test. The p-values are benchmarked against a significance value of 0.05.

Two sample t significance test		
Variable	**P-value**	**Conclusion**
LN(1+age)	0.261	No interaction
LN(Assets)	0.341	No interaction
LN(Grossp w/)	0.120	No interaction
Venture_backed_d	0.000	Yes interaction
Rank_high2_d	0.058	No interaction
Uses_p	0.203	No interaction
Hot2_d	0.171	No interaction
Cold1_d	0.538	No interaction
20days_stdev	0.001	Yes interaction
Trad_vol	0.176	No interaction
Biotech_d	0.097	No interaction
Tech_or_inet_d	0.589	No interaction
all_stdev_qm1	0.018	Yes interaction
all_stdev_qmr1	0.050	Yes interaction
all_stdev_qm_op1	0.009	Yes interaction
2hrs_stdev_qm1	0.042	Yes interaction
2hrs_stdev_qmr1	0.010	Yes interaction
2hrs_stdev_qm_op1	0.203	No interaction
rest_stdev_qm1	0.006	Yes interaction
rest_stdev_qmr1	0.855	No interaction
rest_stdev_qm_op1	0.001	Yes interaction
all_stdev_qm2	0.028	Yes interaction
all_stdev_qmr2	0.204	No interaction
all_stdev_qm_op2	0.157	No interaction
2hrs_stdev_qm2	0.063	No interaction
2hrs_stdev_qmr2	0.821	No interaction
2hrs_stdev_qm_op2	0.214	No interaction
rest_stdev_qm2	0.020	Yes interaction
rest_stdev_qmr2	0.060	No interaction
rest_stdev_qm_op2	0.073	No interaction

Appendix 6.6

Variance Inflation Factors to test for multicollinearity

		Basic	Stdev. Quoted Midpoints				Stdev. QMR		Stdev. QM/OP		
Measure	**Variable**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	ln_age	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	ln_assets	2.9	2.9	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9
	ln_grossp_w	2.7	2.8	2.9	2.9	3.0	2.9	2.7	2.7	2.7	2.7
	rank_high2_d	1.4	1.4	1.4	1.5	1.4	1.5	1.4	1.4	1.5	1.5
	uses_p	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	hot2_d	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	cold1_d	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	trad_vol	1.3	1.5	1.5	1.6	1.6	1.4	1.4	1.4	1.4	1.4
	biotech_d	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	Tech_or_in~d	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	vb_d	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
	20days_stdev	2.1	2.4	2.5	2.7	2.7	2.3	2.6	2.6	2.8	2.9
	20days_stdev*crisis3_d	2.2	2.5	2.7	2.8	2.8	2.8	3.0	2.9	3.0	3.0
Stdev. Quoted Midpoints (QM)	1st all QM		1.7								
	1st all QM * crisis3_d		1.7								
	1st 2hrs QM			2.2	2.3	2.2					
	1st 2hrs QM * crisis3_d			3.3	3.6	3.5					
	1st rest QM			2.0	2.3	2.4					
	1st rest QM * crisis3_d			2.4	3.1	3.5					
	2nd all QM				2.4						
	2nd all QM * crisis3_d				3.0						
	2nd 2hrs QM					2.2					
	2nd rest QM					2.0					
	2nd rest QM * crisis3_d					3.5					
Stdev. Quoted Midpoints Returns (QMR)	1st 2hrs v QMR						1.3				
	1st 2hrs QMR * crisis3_d						2.1				
	1st rest QMR						1.5				
	2nd 2hrs QMR						1.4				
	2nd rest QMR						1.6				
Stdev. Quoted Midpoints divided by Offer Price (QM/OP)	1st all QM/OP							2.0			
	1st all QM/OP * crisis3_d							2.3			
	1st 2hrs QM/OP								1.4	1.4	1.4
	1st rest QM/OP								2.0	2.1	2.2
	1st rest QM/OP * crisis3_d								2.2	2.4	2.5
	2nd all QM/OP									1.6	
	2nd 2hrs QM/OP										1.6
	2nd rest QM/OP										1.7
	Mean VIF	**1.8**	**1.9**	**2.1**	**2.2**	**2.2**	**1.8**	**1.9**	**1.9**	**1.9**	**1.9**