UCLouvain

LOUVAIN
School of Management

Louvain School of Management

To what extent the valuation method and the underwriter discount can influence the valuation of a startup in biotechnology and pharmaceutical industry during its IPO ?

Author(s): Liu Ben
Supervisor(s): Nsabimana André
Academic year 2022-2023
Master [120] : Ingénieur de Gestion à finalité spécialisée

Acknowledgements

First of all, I would like to especially thank my supervisor for this master's thesis, Professor A. Nsabimana for the numerous advice and help he gave me, which greatly contributed to this document.

Secondly, I would like to thank all those who have contributed to this dissertation for their reviews and opinions, which have been a great help along the way.

Finally, I'd like to thank my family and friends for their support throughout these last 5 years of study.

Table of Contents

I. Introduction 4

II. What is a startup? 5

2.1 Characteristics of a startup 5

2.2 Differentiation of a startup 7

2.3 Financement of the startup 8

III. Valuation method for companies 9

3.1 Traditional valuation method 9

I. Discounted cash flow valuation 11

II. Price multiples valuation 13

III. The residual Income Valuation 13

IV. Precedent transaction analysis 15

V. Book value 15

3.2 Role of the Analyst 15

3.3 Use of different method in practice 16

IV. Valuation method for startups 18

4.1 the traditional method of valuation on startups 18

4.2 Valuation Method specific to startups 19

I. Venture Capital method (VCM) 19

III. Berkus method (BM) 22

IV. The Real Option Method 23

V. Valuation during an initial public offering 24

5.1 Reasons of an IPO 24

5.2 The role of the underwriter analyst 25

5.3 Abnormal return of an IPO 25

VI. Biomedical and pharmaceutical sector 26

VII. Methodology and hypothesis 28

VIII. Data analysis 30

8.1 Overview of the IPO market for biotech and pharmaceutical startups 30

8.2 Underwriter Discount Analysis 31

8.3 Valuation Analysis 33

IX. Results 35

9.1 Linear regressions 35

Model 1: Price During IPO and Valuation Method 37

Model 2: Price During IPO and Underwriter Discount Rate 38
Model 3: Price During IPO, Valuation Method, and Underwriter Discount Rate 39
9.2 Machine Learning 40
X. Conclusion, Limitations and future Work 44
XI. References 45
XII. Appendix 56
R Code 56

I. Introduction

The initial public offering is a crucial moment for any company, meaning that it offers its shares to anyone wishing to acquire them. Many factors play a part in determining the success of this event. Among these factors, the amount raised during the operation plays a major role, and is typically determined by a company's professional equity valuation. However, there are many other factors which can influence the final value of a company, both positive and negative.

In this thesis, we will analyze the underwriter's financial independence through the discount rate he will receive following the IPO, and the valuation method used, in order to check whether one of these 2 criteria can influence the over- or undervaluation of the company. In order to narrow down the field of research, we will focus solely on companies that can be considered to be at the end of their start-up phase, which will end with their IPO, operating in the pharmaceutical and biotech sectors.

The analyses made in this document are based on a selection of companies that were considered to be start-ups at the time of their IPO, most of which operate in the healthcare sector. Following the collection of this data, analyses were made of the relationship between the 2 factors mentioned above and the change in share price after one year of listing on the stock market.

II. What is a startup?

2.1 Characteristics of a startup

The business world is filled with diverse types of companies, each with their own unique characteristics and goals. Two types of companies that are often used interchangeably are startups and small and medium-sized enterprises (SMEs). However, we can distinct some unique characteristics concerning startups. Even if no one agrees on a hard definition of a startup, one can still draw clear trends from the literature (Montani et al., 2020). More generally, this question becomes a necessity in order to ensure clear communication with the general public because, according to French and Leyshon, there remains a critical need to "be able to speak the language of mainstream economics" (2010).

Granlund and Taipaleenmäki, have described startups as businesses that are rapidly growing or have already achieved fast growth, specifically in the information and communications technology and biotech industries (2005). Other researchers, such as Birley and Westhead characterized startups as small, newly established independent businesses that are created by individuals to be self-employed (1994).

Some authors agree that one can draw some rather vague characteristics to define a startup (Soloveychik & Sataev, 2021). According to Cockayne, there are five key attributes for this type of company (2019):

The size of the firm: there is not really a precise number as in the definition of an EMS where the number of people must be smaller than one hundred. The author only suggests that the number should be small in order to participate to the startup feeling.

The duration of operation: There seems to have a relationship between duration and startup, it is quite difficult to really define a precise duration since it is often difficult to define the start of a business.

The growth: The startup can be considered as a company’s stage that is prior to a high- growth stage with the absence of a viable product or robust client base.

Informality and hard work: Informality can be seen in the way that startups are structured,

with flat hierarchies and a lack of formal processes and procedures. The informality also extends to the company culture, which is often informal and relaxed, with a focus on teamwork and collaboration. However, this informality is balanced with an intense work ethic, as startups must work hard to establish themselves in a competitive market and grow their business.

Venture Capital: The funding of a startup is also a key component for the development of those. Indeed, the ultimate goal of a startup is to grow exponentially and reach an exit event for the investors (Feld & Mendelson, 2016). To achieve this goal and move out of the start-up phase, companies need funding to start and develop the project. This is often done through venture capital, making venture capital a key element in the definition of a startup.

Some other authors come with a definition that are much stricter. Davila and Foster define a startup as a company with between 50 and 150 employees, less than 10 years in business, independent and geographically limited in its operations (2005). In research from Kollman et al., startups must have less than ten years of operation, have innovative products and have significant employee or sales (2016).

Sanyal and Mann tried to define a startup thanks to its financial structure which should differ from other stages of the lifecycle of a company (2010). They discovered that startups typically have less transparent information and more specific assets compared to established or ongoing businesses. They often rely heavily on human capital as assets, but lack traditional collateral and reputation, which makes it difficult for them to borrow from external sources. As a result, startups are more dependent on internal sources of funding for their financial needs.

Due to the existence of several different, and sometimes even contradictory, definitions in literature. In this master thesis, we will adopt a rather comprehensive definition of startup and wrap up the main components of the different definitions: “new businesses which are started from scratch” (Kolvereid & Isaksen, 2006).

2.2 Differentiation of a startup

During this section, we have compared a lot of start-ups to traditional SMEs, but what are the fundamental differences between them? Startups and SMEs are both types of "small" businesses, but they differ in several ways. SMEs are small and medium-sized enterprises, while startups are newly established companies that are still in the early stages of development. SMEs are typically more established and have been in operation for a longer time than startups. Startups are often focused on innovation and growth, while SMEs are more focused on maintaining their current operations and expanding their customer base. Indeed, a startup is seeking to grow exponentially after the facing of the Death Valley phase (Hudson & Khazragui, 2013), it's a phase the the company have to lunch and adapt its product to the market and obtain some income and thus profits. This phase is called so because it has a very low rate of survival. However, after this phase, the startup is seeking to grow exponentially as a upside down J (called J curve) (Aulet, 2013).

Another difference between startups and SMEs is their approach to revenue generation. Startups often rely on private funding such as venture capital funding or crowdfunding to finance their growth, while SMEs typically rely on traditional financing methods (bank loans or personal contribution). Startups are also more likely to offer free services to attract customers and generate traffic, while SMEs are more likely to charge for their services from the beginning due to the low growth that an SME can expect, they must seek to be profitable as quickly as possible and generate revenue on a regular basis (Lisanti & Mariani, 2016).

In the field of innovation, SMEs are often overlooked in innovation management theories that are rooted in the discipline and practices of large, R&D-intensive companies. However, although the rationale and importance of adopting open innovation may vary depending on the R&D intensity of SMEs, SMEs can be innovative and engage in open innovation practices. SMEs can work with different types of OI partners depending on their R&D intensity (Dooley & O'Sullivan, 2023).

In general, startups and SMEs have similar business characteristics, but differ in their stage of development, approach to monetization, and focus on innovation.

Some authors try to make a summary of these differences. Indeed, according to Aulet and

Murray, a startup differs from other SMEs in that it has a high level of innovation whether it is in terms of technology, internal processes, or even business models. The ability to access new sources of funding that enable it to expand more quickly than SMEs, and the ability to penetrate global markets via the Internet using innovative methods (2013).

2.3 Financement of the startup

Startups need funding to emerge and grow. There are many financing options for entrepreneurs. Bootstrapping is the most common method for startups to finance their business using personal savings, credit cards and loans (Mitchellfrom, 2016). Another option is venture capital, where investors provide funding in exchange for a stake in a company. Corporate venture capital is a type of venture capital where established companies invest in startups related to their business. This type of investment can provide funding for start-ups, but also access to the resources and experience of established companies (Fazekas, 2016).

Another option for funding startups is crowdfunding, which involves raising small amounts of money from a large number of people through online platforms. Crowdfunding can be a great option for startups that offer products or services that appeal to a large number of people. Angel investors are another option for startups where high net worth individuals provide funding in exchange for a stake in the company. Angel investors can also provide experience and networking to startups. In addition to all the traditional funding options, startups can also explore other funding options such as revenue-based funding and grants. Grants founding are grants provided by governments, foundations and other organizations to support start-ups and thus, push for innovative ideas. Startups can also participate in startup accelerators and incubators that provide funding, mentorship, and resources to help startups grow and succeed.

III. Valuation method for companies

Valuation methods are a crucial aspect in determining the value of a company or asset. In this part of the literature review, we will explore the various traditional approaches used in valuing a company. We will also examine the importance of considering both the quantitative and qualitative aspects of a business when conducting a valuation. Furthermore, we will discuss the role of analysts and forecaster and how they are able to affluence their valuation. Finally, a section will be devoted to the application of these valuation methods in practice which can be much more nuanced than in theory.

3.1 Traditional valuation method

The valuation model can be considered as a mechanism that converts a set of observations or forecast of a company into a market value by taking into account different economic variables (Dimitrou, 2017). In order to have an efficient and comprehensive valuation model, it requires two main components: a clear and available data concerning the company and an analytical review of the valuation models (Barker, 2001). There exists various valuation models which in theory have all the same goal: discount a firm's future cashflows by investors desired rate of return (Thomas & Gup, 2009). Valuation must adhere to established financial theory and also be practical. Both are crucial elements in finding a solution. Additionally, the accuracy of a valuation model is contingent on the quality of the accounting it incorporates (Penman, 2016). According to Stowe et al., valuation is a multi-faceted process that involves several steps to arrive at a final value (2007):

Step 1: Acquiring a thorough understanding of the business being valued.

Step 2: Projecting the future performance of the company.

Step 3: Choosing the most suitable valuation model for the task at hand.

Step 4: Translating forecasts into a final valuation.

Step 5: Making an investment decision based on the results.

According to Bertinetti et al., we can basically classify nearly all the theoretical valuation technique into five valuation method class (2006):

Method Class	Method Technique
Net Assets based Methods	Embedded Value Appraisal Value
Earnings-based Methods	Discounted Shareholder Profit Discounted Earnings Heuristic methods
Cash flows-based Methods	Dividend Discounted Model Discounted Cash Flows Gordon Growth Model Adjusted Present Value HOLT-CFROI
Hybrid Methods	Economic Value Added Regulatory Asset Based methods
Market ratios Methods	Comparable companies

Table 1: Valuation method classes and techniques (Bertinetti et al., 2006)

The principle of valuing a company is based on a simple observation from an investor's point of view: The value of an investment is given by the future consumption it is expected to yield, discounted by the risk that this will not happen and by the value of money over time (risk free rate). Since with cash one can buy consumption, the value of a company is ultimately given by the expected net cash dividend. Therefore, the simplest value model appears (dividend discount model) (Rubinstein, 1976):

$$\text{Value}_{\,t} = \sum_{\tau=t+1}^{\infty} \frac{d_\tau}{R_{t\tau}},$$

- R_{tc} *= The risk-adjusted discount rate at time* τ *seen at t*
- d_c *= The cash dividend received at time* τ

However, this simple point of view has three major issues. First of all, the infinite time horizon, which is not practical since the further into the future, the more uncertain the valuation becomes. Moreover, another foundational concept of finance states that dividends are zero net present value (Miller & Modigliani, 1961). Indeed, the dividend irrelevance proposition suggests that the distribution of dividends to investors does not affect the overall value generated for investors, and that dividend policies are separate from value creation. Third, the discount rate is rather uncertain or even unknown. Although we have models to estimate the discount rate (e.g., the cost of capital derived from the capital asset pricing model), it remains extremely sensitive to unknown future factors and numerous assumptions that have been made (Penman, 2016).

Let's take a closer look at the main models used in finance to overcome one or more of the shortcomings of the discounted dividend model in order to value a firm correctly.

I. Discounted cash flow valuation

This model deals with the issues about the dividend irrelevance and the infinite time horizon. The principle of this valuation technique is to discount not dividends but Free cash flow to the firm which is the cash flow available to the company's suppliers of capital after all operating expenses (including taxes) have been paid and necessary investments in working capital and fixed capital have been made. FCFF is the cash flow from operations minus capital expenditures and in this model, we will compute a terminal value which allows us to easily estimate the long-term value of a company. Therefore, the value of a company can be expressed by this formula (stowe et al, 2007):

$$\text{Firm value } = \sum_{t=1}^{\infty} \frac{\text{FCFF}_t}{(1 + \text{WACC}^t)}$$

- $FCFF_t$ = *The free cash flow to the firm generated at time* τ
- $WACC = \frac{MV\ (Debt)}{MV\ (Debt)+MV(\ Equity)} r_d(1 - \ Tax\ rate) + \frac{MV(\ Equity)}{MV(Debt)+MV(\ Equity)} r =$

  $Weighted\ average\ cost\ of\ capital$

By assuming a constant growth rate of the firm g such that the FCFF of a period is the previous one multiplied by (1 + g), then we can assume that the value of the firm is equal to:

$$\text{Firm value} = \frac{\text{FCFF}_1}{\text{WACC} - g} = \frac{\text{FCFF}_0(1+g)}{W_{\text{WCC}} - g}$$

For a question of representation of reality, the two-stage or three-stage discounted cash flows model seems more correct. In this model, the firm is considered to have a period of rapid growth and after a certain number of periods the growth rate decline either immediately or not to a sustainable infinite growth (smaller than the growth of the global economy otherwise after a certain period, the firm would be larger than the whole economy):

$$\text{Firm value} = \sum_{t=1}^{n} \frac{\text{FCFF}_t}{(1+\text{WACC}^t} + \frac{\text{FCFF}_{n+1}}{(\text{WACC}-g)} \frac{1}{(1+\text{WACC})^n}$$

Unfortunately, the free cash flows, like dividends, is not an accurate measure of value because it is based on an accounting equation that treats investments as reductions in value rather than as value-adding activities. Indeed, Free cash flow= cash from operations- cash investment. Thus, a firm can increase its free cash flows by reducing investments. This is counterintuitive, as investments are typically seen as a source of value, and it can lead to firms with strong cash from operations but negative free cash flows being incorrectly viewed as having low value (Penman, 2011). Furthermore, this model has several key assumptions and limitations, including the assumption of constant growth and the requirement of a stable and predictable business environment.

II. Price multiples valuation

The Price multiples model is a method used to value a company by comparing it to similar companies in the same industry. The model typically uses financial ratios such as the price-to-earnings ratio (P/E ratio) or the enterprise value-to-earnings before interest, taxes, depreciation, and amortization (EV/EBITDA) ratio to compare the company being valued to others in its industry. These ratios are used to determine the relative value of a company based on its earnings or revenues (Stowe et al, 2007). By applying industry-specific multiples and comparing them to similar companies, this approach allows us to estimate a company's fair value. The use of multiple valuations is especially useful when there is a lack of publicly available information about the firm being valued or when the company operates in a relatively stable industry (Penman, 2011).

However, this model handles also numerous of market assumptions that are not always realistic such as the availability of comparable companies, the market efficiency or even the fact that similar companies have similar growth, risk and financial performance (Stretcher & Johnson, 2011).

III. The residual Income Valuation

Traditional financial statements are created to reflect earnings that are available to owners, especially the income statement. To reflect the cost of debt capital, which takes the form of interest expense, a charge is included in net income. However, no deduction is made for dividends or other charges related to equity capital. Indeed, when an investor is reading an income statement, he is able to know what's the earning that the company made a particular year and thus deduct his return. However, the use of traditional accounting enables owners to assess whether earnings are sufficient to offset opportunity costs. Contrarily, the financial concept of equity capital, which gives the opportunity costs of shareholders, explicitly deducts the estimated cost of equity capital from the economic concept of residual income (Stowe et al, 2007). This type of Computation of the value of the Equity of a specific company can be done with this formula:

$$V_0 = B_0 + \sum_{t=1}^{\infty} \frac{\mathrm{RI}_t}{(1+r)^t} = B_0 + \sum_{t=1}^{\infty} \frac{E_t - rB_{t-1}}{(1+r)^t}$$

where

V_0 = value of a share of stock today ($t = 0$)

B_0 = current per-share book value of equity

B_t = expected per-share book value of equity at any time t

r = required rate of return on equity (cost of equity)

E_t = expected EPS for period t

RI_t = expected per-share residual income, equal to $E_t - rB_{t-1}$

A very handy and common way to compute the residual income is the economic value added (EVA), this calculation of the residual income is done as:

$$\mathrm{EVA} = \mathrm{NOPAT} - (\mathrm{C\%} \times \mathrm{TC})$$

where

NOPAT = the company's net operation profit after taxes

C% = the cost of capital

TC = total capital

However, as every method this valuation technique has its limitations and unrealistic assumptions such as the stability over time of the residual income and cost of capital. Furthermore, this method has a limited scope. Indeed, it focuses only on economic value generated by operations and none by the non-operating assets, such as financial investment or real estate that can also play a huge role in the valuation of a company.

IV. Precedent transaction analysis

the previous transaction analysis is derived from the multiples method. Indeed, this valuation technique is based on the examination of prices paid in previous similar transactions. This approach is most often used in M&A transactions and helps to find the market value of a company based on historical deals. To arrive at an accurate valuation estimate, PTA typically involves analyzing various transaction multiples, including production, reserves, and cash flow multiples. To prevent significant departures from the actual market value, it is essential to apply these multiples correctly and take into account elements like the correlation between multiples and the reserves-to-production ratio as well as the impact of the profit margin on transaction multiples (Dajdica & Byrne, 2020).

V. Book value

By examining the financial statements and the balance sheet of a company and concentrating on its book value (net equity) and earnings, book value valuation is a technique used to estimate the value of a company. When all assets are subtracted from all liabilities, a company's net worth is represented by its book value. The relative weighting of earnings and book value in valuation models can change depending on elements like expected adaptation, industry sector, and accounting practices (Rabier, 2018). Research has shown that accounting information, including book value and earnings, is relevant for valuing share prices (Rezende, 2016). However, the value relevance of these factors may change under different circumstances, such as negative earnings or negative book value.

3.2 Role of the Analyst

Forecasts of corporate earnings made by analysts are crucial in determining the value of stocks on the market. Even minor differences between actual earnings and the consensus forecast of analysts can lead to significant changes in stock prices (Darrough & Russell, 2002). However, financial analysts are constantly unconsciously biased, face incentives and cognitive challenges in their forecast. According to Easterwood and Nutt, analysts tend to underreact to

negative news and overreact to positive ones (1999). Analysts that focus only on one single company have to maintain a good relationship with the company and thus they may not react properly to bad news concerning that company (Darrough & Russel, 2002). Furthermore, the recommendations made by underwriter analysts tend to perform more poorly than unaffiliated brokers (Michaely & Womack, 1999). More generally, the more neutral the analyst is towards both his clients and the company he is analysing, the more accurate his prediction will be of reality (Zhang & Wei, 2020).

On top of all these factors, the performance of an analyst is highly influenced by numerous other elements that are not under control. Indeed, according to O'Brien, the most recent forecast tends to be more accurate than the consensus forecast (1988). Moreover, Mikhail et al. who found that individual analyst experience increases forecast accuracy (1997). Clement also found that analysts' forecast accuracy increases as they have more resources and decreases as the complexity of the task increases (1999).

3.3 Use of different method in practice

The analysts' analysis is seen as a "black box" in the literature (Bradshaw, 2011). Indeed, they tend to stay quite mysterious about their valuation method and all the modifications applied to the theorical model seen before (Viebig et al., 2008) (Lee & Lee, 2015). Indeed, analysts commonly make subjective adjustments in order to obtain a more realistic and reliable value (Bonini & Kerl, 2014). However, a clear trend is emerging analysts have a preference for using earnings multiples and the discounted cash flow model (Imam et al., 2013). even if they still prefer the DCF model over the multiples valuation (Iman et al., 2008) Concerning the performance of these two models, Demirakos et al. claim that earnings multiples have better result than DCF models (2010). However, many researchers argue that over the last decade, book value multiples have performed better than earnings multiples (Nissim, 2011) (Deng et al., 2009) (Lie & Lie, 2002). Although the literature tends to show that the multiple books has performed better in the past, recent studies tend to claim that the difference in performance has dastardly diminished and has even become insignificant (Erkilet et al., 2021).

The choice of a valuation method is determined mainly by 3 factors:

1. the sector or industry in which the company operates (Demirakos et al, 2004) (Imam et al., 2008).
2. the stage of business growth of the company (Demirakos et al, 2010).
3. The individual preference of the analyst (lee, 2003) (Lundholm & Sloan, 2013).

In summary, the effectiveness of one method of valuation over another is not as clear as it seems and can change over time. Therefore, there is no clear best method, it is all a matter of circumstances.

IV. Valuation method for startups

4.1 the traditional method of valuation on startups.

The traditional methods of valuation such as the cost approach, income approach, and market approach are not effective for valuing startups (Dehghan-Eshratabad & Albadvi, 2008) (Miloud et al., 2012). The absence of key information such as past revenue or cash flow, market data, and the intangible nature of a startup's assets make it difficult to apply these methods. The cost approach, which relies on the current value of assets and liabilities, is particularly ill-suited for startups (Dusatkova & Zinecker ,2016). It is static and does not account for the company's future growth. This is also pointed out by De Olivera and Zotes, who suggest that the cost approach is not suitable for assessing the economic capital of startups (2008). The value of a startup is in the idea created by the founders and its subsequent development, not in its assets, because new startups usually have very few tangible assets and are undercapitalized (Krishna et al., 2016).

The application of the discounted cash flow method, which is part of the income approach, to value startups is problematic (Sander & Kõomägi, 2007). This is because the discounted cash flow method relies on fixed assumptions about project payoffs, but the payoffs for startups are uncertain and probabilistic (Shestakov, 2015). Additionally, the terminal value is particularly significant for young companies (Reis and Augusto ,2013). The terminal value can make up as much as 90% of the total value of the company, however, determining the terminal value for a startup is complex as it is not possible to consistently establish certain elements of the terminal value (Damodaran, 2016).

Traditional valuation methods rely on the assumption that the capital market is efficient, (Stankevičienė & Žinytė, 2011). This may be more applicable in the case of public capital markets where legal regulations mandate that public companies disclose all relevant information to stakeholders (Ge et al., 2005). However, this assumption may not hold as well in private capital markets where there is a higher degree of information asymmetry. Due to that the market multiple method become quite hard to apply without accurate information.

4.2 Valuation Method specific to startups

In this part of the literature review, we will assess some valuation method that are specific for the valuation of startups. These methods are still not "perfect" since they all have significant limits (Damiano et al., 2020).

I. Venture Capital method (VCM)

The VCM is derivated from the DCF method which rely on the venture capitalist point of view of the company and the market (Demodaran, 2009). Unlike the DCF, the VCM takes into account the risk borne by these young companies in the valuation. Indeed, this method calculates the value of the startup by using either future cash flows of comparables and market multiple and by discounting using a very high rate. This method is used almost exclusively for pre-money valuation (Nursaadah & Faturohman, 2022). The formula of this method can be written as following (Keeley et al., 1996):

$$\text{Net Present Value } (NPV) \text{ pre-money} = \frac{P_{T,VC}}{\prod_{t=1}^{T}(1+R_{t,VC})} - \sum_{t=1}^{T} \frac{I_{t,VC}}{\prod_{\tau=1}^{t}(1+R_{\tau,VC})} - I_{0,VC}$$

- $P_{T,VC} =$ *venture capitalist's estimate of company value at* T
- $I_{t,VC} =$ *venture capitalist's estimate of additional investment required at time t*
- $R_{t,VC} =$ *venture capitalist's discount rate*
- $I_{0,VC} =$ *net present value of initial investment*

This method is applied following 3 distinct phases:

The first step consists of assessing expected future cash flows in a time horizon from 2 to 5 years (Damodaran, 2009). This time horizon corresponds in most cases at the period that the venture capital fund is considering selling its holdings or making an IPO (Sammut, 2012). This projection into the future is often made on the basis of the scenario that is considered most likely by the analyst and not on a weighted average of possible scenarios.

The second step is to determine the terminal value at the end of the time horizon considered in part 1. The terminal value can be calculated using the multiples method since the company will be more mature and therefore more likely to have comparable public companies. This

terminal value will then be discounted at a very high rate given the risks taken by the venture capitalist (the rate chosen will be the desired rate of return on investment) (Bhagat, 2014).

and finally, in return for the investment made, the venture capitalist gets equity shares. In order to know the share requested as compensation for the risk taken, the post-money value of the company will also be calculated, which will be equal to the sum of the net present value pre-money and the amount of the investment. Therefore, the venture capitalist needs at least the equivalent of the amount invested divided by the net present value of the company when it makes a profit in equity to get into the deal (Visconti, 2020).

This valuation method has essentially 2 major limitations. On the one hand, some authors consider it wrong to incorporate the default risk in the discount rate used to calculate the NPV in an arbitrary way (Steffens & Douglas, 2007). In addition, this technique assumes that the default risk of a start-up remains constant throughout the life cycle of the company. On the other hand, as discussed in the scenarios, analysts focus only on the most likely scenario and not on other scenarios that may occur (Babiarz, 2016).

II. First Chicago method (FCM)

The FCM is continuation of the VCM by applying lower discount rate and by replacing the terminal value by the weighted average of the net present value of the company under three different type of scenarios (the worst case, the normal case and the best case) (Majercakova & Mittelman, 2018). It is used especially for post-money startups (Nursaadah & Faturohman, 2022). The formula can be written as :

$$PV_i = \sum_{t=1}^{h} \frac{CF_t^i}{(1+r)^t} + \frac{TV_i}{(1+r)^h} \rightarrow PV = \sum_{i=1}^{3} p_i PV_i$$

- *I = scenario index*
- *H = time to exit*
- *PV = present value*
- *CF_t^i = cash flows in period t*
- *TV = terminal value*

This method is developed in 3 phases:

To start with, the analyst will define 3 distinct realistic scenarios which are in most cases an optimistic scenario where a big increase in sales is expected, an intermediate scenario where events unfold in a reasonable way according to the analyst and a bad scenario where the company goes bankrupt.

In a second step, the analyst must calculate the cost of divestiture by considering the company that will become a going concern. In most cases, this analysis is done using the multiples method, taking into account macroeconomic health. This will then be the terminal value.

Finally, with all these forecasts, the analyst can determine the value of the startup at the time of investment by making a weighted sum of the net present value of each scenario (Hashemi, 2015).

The first chicago method has the advantage over the VCM of having several possible scenarios, making it much more realistic in the face of the high volatility that a startup can experience, thus allowing for a more realistic value. Extending this advantage, the FCM allows for the creation of three different scenarios to identify specific risks for each startup. However, this method also has limitations such as not matching startups that are already generating revenues or not taking into account potential changes in situation during the life of the startup (Demyanova, 2018).

III. Berkus method (BM)

The BM is a method based on subjective judgment of the investor on the assessment of five key success factors that Dave Berkus has highlighted (Amis & Stevenson, 2001). This valuation technique suits startups in a early/pre-revenue stage and is particularly appropriate for companies that is on the track to achieve about 20 million dollars revenues by the fifth year of the company (Berkus, 2016). The five key success factor is these:

If Exists	Add to company Value up to
Sound Idea (basic value)	$1/2 million
Prototype (reducing technology risk)	$1/2 million
Quality Management Team (reducing execution risk)	$1/2 million
Strategic relationships (reducing market risk)	$1/2 million
Product Rollout or Sales (reducing production risk)	$1/2 million

Table 2: Key success factor valuation (Berkus, 2016)

The Berkus method is very effective and useful if you only focus on the success factors of a startup (Payne, 2016). It is considered a very good implementation and adaptation of the scorecard method (Kowlessar, 2016). However, the BM has relatively harsh limitations as it depends solely on the subjectivity of the analyst who is assessing these 5 factors. As a result, the value can vary greatly depending on the approach and point of view of each individual.

IV. The Real Option Method

The real option method is derived from the option theory developed by Black & Scholes (1973). This valuation method is based on the fact that the choice of a company's directors and managers can be considered as a financial option (put or call). These decisions, which may or may not be taken, are made in an uncertain environment in relation to the information held by the company. For example, a company identifies a business opportunity (which is similar to an option) requiring an investment at time t and an additional investment at time t+1. If at t+1, the opportunity has become even more attractive, this would mean that the net present value of the investment would be higher than if the option had been exercised. The option is therefore exercised, and the project can continue. On the other hand, if in t+1, the investment seems much less attractive than in t, the company may stop investing and, as a result, the option is no longer exercised, and the company will have lost the option price paid at time t (Frykman & Tolleryd, 2012).

With this valuation method, the entreprise value can be determined as follows:

$$\text{Enterprise Value} = \text{Value of existing operation} + \text{Value of the company portfolio of real options}$$

Unfortunately, this model is not always appropriate for start-ups. It is extremely difficult to give a price and to list all the options available for a particular start-up. As a result, this technique is more conceptual in business terms than a real valuation technique.

V. Valuation during an initial public offering

An initial public offering (IPO) is a process by which privately held (often young) companies raise capital by issuing shares of their stock to the public for the first time (Joshipura et al., 2023).

5.1 Reasons of an IPO

Going public represents a major milestone for unlisted or private companies but why should they go public. We can highlight four major reasons. First, the firm itself can raise capital at a lower cost in order to make new investments or to plan loans repayment (Ljungqvist, 2007). Secondly, the the firm's owners such as the venture capital or the entrepreneur can cash out a part or the totality of their shares for other expenditure or for diversifying their portfolio of investment (Loughran & Ritter, 2002). Finally, by going public, the company can reach other indirect benefits such as enhancing the company's trademarks, increasing corporate publicity or even attracting new talents in their structure (Demers & Lewellen, 2003).

However, despite all these advantages for going publiv, thereare still counterparts associated with this process of IPO. As Smart and Zutter (2003) have noted, it can lead to a loss of control for these parties. Indeed, new shareholders who gain voting rights through the process which can dilute the voting rights of the founders and current shareholders (Dolvin & Jordan ,2008). Furthermore, IPO firms also have to bear direct costs of public listing including listing fees, underwriting fees, brokerage, legal and accounting fees, share registry costs, and also other indirect costs, such as the increased cost of preparing annual financial reports (Loughran & Ritter, 2002). In addition to these consequences, firms that go through an IPO take on additional legal and moral obligations in the form of rigid information transparency and disclosure requirements to act according to the best interests of the larger group of shareholders (Ritter, 1987). This can compromise the company's competitive advantage by being obligated to increase their information disclosure about current operations and expansion plans as required by security exchange commissions (Habib & Ljungqvist, 2001).

5.2 The role of the underwriter analyst

Underwriter analysts usually are part of underwriting banks, typically large investment or commercial banks, handle the process of issuing an initial public offering for a company in exchange for underwriting fees, known as the "underwriting spread" (Chen & Mohan, 2002). They purchase the shares being sold to the public by the issuing company and then resell them to the public (Chahine, 2008). As such, underwriters are responsible for evaluating the IPO firms and determining the appropriate offer price and price range that will result in a successful listing. However, underwriters may also take on the risk of potentially non-full IPO subscription and may buy the IPO company at a discount to compensate for this risk (Lowry & Shu, 2002). Additionally, underwriters may underprice the IPO firm to attract more investors, reduce marketing efforts, and avoid non-full IPO subscription (Carter et al., 1998).

5.3 Abnormal return of an IPO

The underpricing of a company's shares during its IPO gets a lot of attention from the financial community these years. Indeed, numerous of authors have discovered all around the world a positive abnormal performance of stocks during the first day just after the issuing of their share (Loughran & Ritter, 2004) (Jamaani &Alidarous, 2019) (Chen et al., 2017). Several theoretical studies have been carried out to find the cause of this underpricing. According to Yusup, the abnormal initial returns is largely due to investors' overevaluation and overreaction (2022). While for others, the underpricing phenomenon is due to the existence of asymmetry among investors and the issuing firm due to the third part which is the underwriter (Jamaani & Alidarous, 2019). Several solutions have been proposed to resolve this issue. Jamaani and Alidarous suggest to apply the Entrepreneurial Wealth Losses theory because this solves the probleme of information asymmetry while taking into account the intrinsic relationship between IPO underpricing and underwriter reputation (2019). Duong et al. propose a stricter trading rule on market manipulation to reduce this effect which will also have positive impact on initial public offerings, higher subscription levels, and greater trading volume, as well as lower listing fees and improved long-term performance after the IPO (2021).

VI. Biomedical and pharmaceutical sector

According to Malerba & Orsenigo, the historical development of the pharmaceutical industry using an evolutionary approach to economic and industrial change (2015). They have identified four main eras: the formative stages (from the late 1800s to War World II), the Golden Age (the 1940s to the mid-1970s), the biotechnology revolution (the 1970s to the new millennium, approximately) and the Winter of Discontent (the first decade of the new century). Within all these epochs, their article discusses the main trends in technology, firms' strategies and structures, patterns of competition, demand, regulation, and institutional developments.

1. Formative stages: During this era, the pharmaceutical industry is in its early stages of development. This was due to particularly lax legislation, limited scientific knowledge and the concentration of natural-source medicines. The sector was highly fragmented, with many small companies operating in local, niche markets.

2. Golden Age: This era is characterized by the emergence of large pharmaceutical companies with greater clout to develop new drugs, especially antibiotics. The industry underwent strong growth during this period, thanks in particular to increasing demand for medicines and the emergence of new production and research technologies that enabled the mass production of synthetic products more effective than those found naturally. Thanks to the arrival of these major players, the sector has become more professional and internationalized in order to conquer new markets.

3. Biotechnology revolution: This era is particularly characterized by the use of biotechnology, which has created a revolution in many areas of medicine. Biotechnology has enabled the development and engineering of medicines thanks to the power of electronic machines. What's more, the sector has undergone a real boost in its capacity to research and develop, thanks to companies investing massively in new products.

4. Winter of Discontent: Unfortunately, this latest era in the historical development of the pharmaceutical industry is characterized by a decline in inventiveness and the emergence of doubts as to the sustainable growth of an industry whose business model has been completely overtaken by modern thinking. Public perception is also at half-mast due to the many scandals

the sector has suffered and the constantly rising cost of medicines. As a result, many popular drugs have been withdrawn from the market. The primary source of this change in climate is certainly the growing concern about the recent revolution in the patent system and, more generally, access to healthcare services in both developing countries and the US.

Finance has had an impact on the progression of the pharmaceutical sector. The increasing demand for medications boosted by population expansion, improved living conditions and unaddressed medical necessities has turned the development of drugs into a lucrative enterprise. Additionally, the expansion of healthcare insurance in the United States and social welfare programs in Europe have created a substantial, affluent and well-structured market, for companies operating within this industry.

VII. Methodology and hypothesis

This master thesis topic therefore focuses on whether the valuation methodology of a stock at initial public offering and the independence of the underwriter have an over/under valuation effect on the fair value of biotech and pharma startup stocks. To do this, first of all, information gathering is essential. There are 3 factors to take into account in order for this data to be meaningful in the context of this work:

1) the IPOs must concern startups: As seen earlier, the definition of startups is very vague. However, there are some trends that we can draw from it. Therefore, in this paper, we will focus only on relatively "small" companies subscribing to IPOs in which the final amount raised can be considered as low (>$350 million in market cap), whose prospects of evolution can be exponential with a relatively high-risk level.

2) the IPOs must concern companies operating in the fields of biotechnology and/or pharmaceuticals: the sector in which the company is to operate (or will operate if it does not have a viable product) must be related to the world of health care or life sciences, whether it be in proposing new drugs, equipment or even in the field of medical IT. These companies can operate from any state in the world. However, in the interest of gathering information, we will only focus on companies listed on US exchanges whose prospectuses can be found on sec.gov. Another constraint that this site imposes on us is the fact that we will only select companies whose IPO was completed after 2000. This is on the one hand a good thing because the stock market being quite changeable and adapting to the different advances in financial research can therefore give relatively different results depending on the time of research.

3) the method of valuation used at the time of the IPO and the discount rate offered to the underwriter must be mentioned in the company's first filed prospectus: It was perhaps this point that was the most challenging. Indeed, in many propestuses, the underwriter does not disclose exactly the main valuation method used by the analyst; the prospectus only gives very general frameworks regarding the method used to reach the IPO amount. Sometimes this document gives terms in the valuation that are characteristic of a valuation method without necessarily citing the method itself. In this case, I will assume that the implicit method was

the main method of valuation of the company. Regarding the discount rate that the underwriter obtains by realizing the IPO of a company, it is often around 7% of the total amount raised at the time of the company's public debut. However, according to D. Westenberg, the 7% rate is only used in slightly less than 40% of cases (2012). Therefore, we can consider that if the analyst receives a higher percentage, he may be tempted to push the IPO price up in order to generate more capital gains and ultimately more bonuses at the end of the year.

With these 3 criteria in mind, the selection was made using the finviz.com website, which allows companies to be filtered by market cap, sector, IPO date... As a result, 150 companies corresponding to the conditions were selected for the test. Following this selection, a check was carried out on the sec.gov website, which contains all the prospectuses of these companies. Unfortunately, for many of the companies, the valuation method was very unclear and/or non-transparent, making it impossible with public data to categorize the main method used. In the end, only 81 companies were retained for the final analysis.

The 2 hypotheses that will be verified in this master thesis are therefore:

1) The valuation method of a startup during the IPO operating in the biotechnology or pharmaceutical field influences the fair value of the company's shares once on the public market.

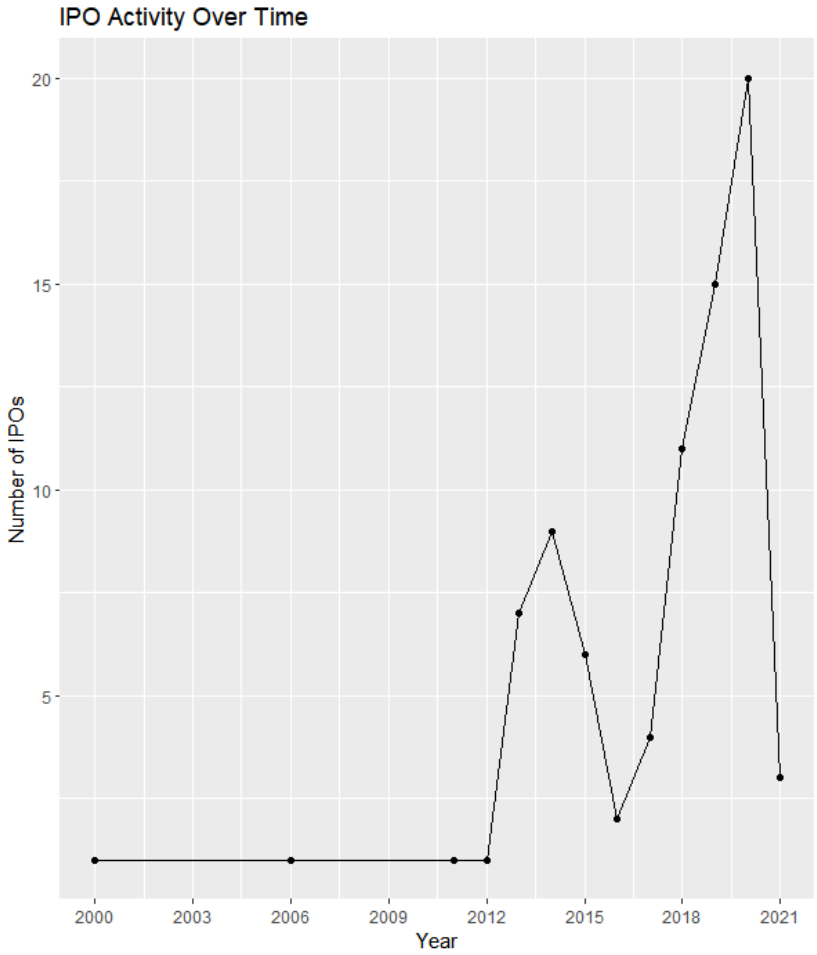
2) The financial independence of the underwriter during the IPO of a biotech or pharmaceutical startup influences the fair value of the company's shares once on the public market.

To do this, we will first run a regression taking into account the price of the stock one year after its IPO compared to its IPO price, the valuation method used and the discount percentage of the underwriter. This will allow us to highlight whether one of the two characteristics may be significant or not. In a second step, market learning methods will be applied on the basic database by simplifying the share price by a binary value (1 if the value of the company after one year on the public market is higher than its IPO value and -1 if it is the opposite). Thanks to this second part, we will be able to validate if one or the other of the 2 basic hypotheses play a role in the overvaluation or undervaluation of a company. Indeed, if the results of machine learning are significantly above 50%, we will be able to assert that there is a link between one or the other factor and the fact of overvaluing or undervaluing a stock.

VIII. Data analysis

8.1 Overview of the IPO market for biotech and pharmaceutical startups

The number of IPOs in a year fluctuates due to many political and macroeconomic factors. Indeed, it is easy to understand that the more companies that go public, the healthier the overall economy can be considered. Indeed, if companies need large amounts of funding in order to grow and develop, they judge that the demand for their services/products will follow. Unfortunately, when selecting the startups for this study, a time-condensing choice had to be made that biased the health indicator in the health care industry. Regarding the distribution of the dataset used for the analysis, it is distributed as follows:

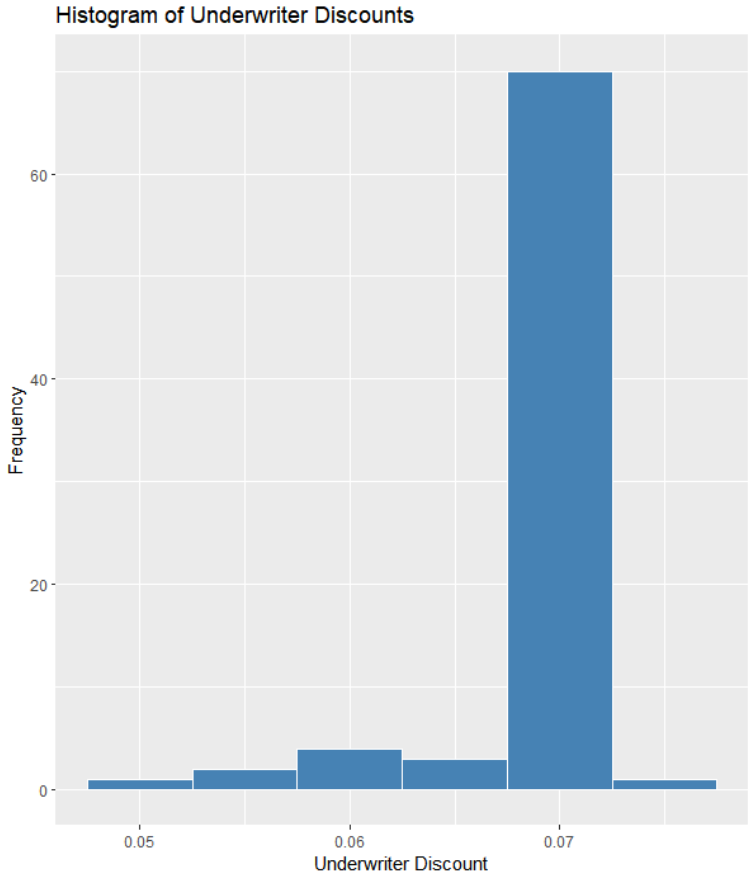


As the graph shows, the amount of IPO peaks in 2019-2020, which was in fact performant

years for the financial market. Indeed, the global return during those years was quite high compared to the average return. For example, by taking into account the S&P 500, this index has a growth of more than 16% and 26% in those years compared to a mean return of 10% since the creation of this market index (I. Webster, 2022). Furthermore, the macroeconomic condition such as the interest rates also impact the IPO activity. Indeed, when the interest rates are low, the company can borrow money rather than go public, while the economy is strong, it can lead to a high level of investor confidence and thus can increase the number of IPO applications.

8.2 Underwriter Discount Analysis

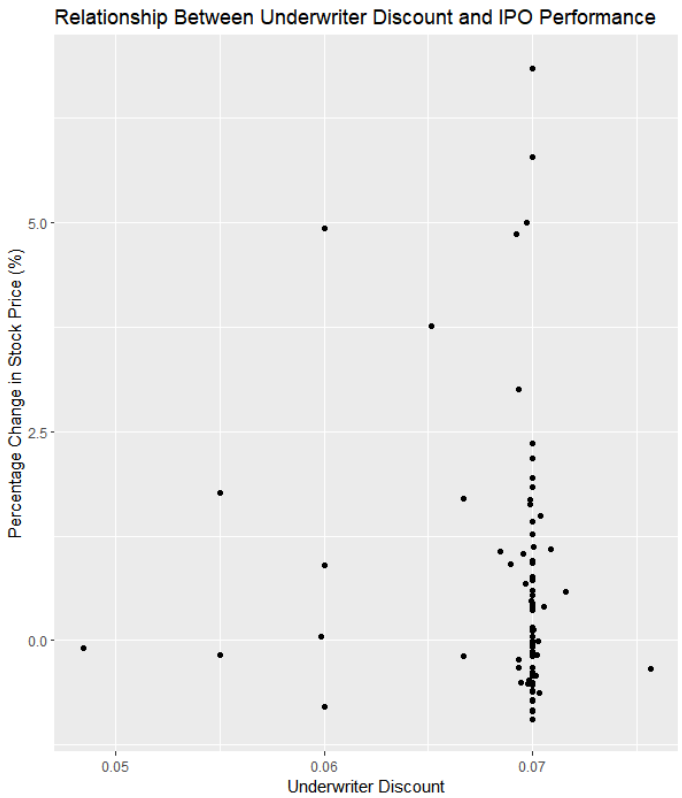
As mentioned previously, the underwriter discount is mostly 7%. However, there are still some deviations from this industry standard. As you can see on the following graph from the build dataset for this paper, this statement is totally verified:



About the underwriter discounts in our dataset, more than 68/81 of the IPOs analysed have a discount rate of about 7%, which is approximately 75%. This rate is much higher than the

report by D. Westenberg which stated that about 40% of IPOs had an underwriter rate of 7%. This large difference can be explained by the fact that since the analysis only focuses on startup IPOs which by definition are not major IPOs that can raise several billion dollars. When such large companies go public, underwriters tend to lower their percentages so that their work is in line with the dollar amount and not the percentage. Furthermore, with a median rate of 7%, it can be said that biotech and pharmaceutical startups are willing to pay a relatively high premium in order to go public and raise funds. It should be noted that the underwriter's discount is not the only cost associated with an IPO. Companies also face additional expenses, such as legal and accounting fees, marketing expenses and stock exchange fees. These costs can vary considerably depending on the size and complexity of the IPO and can have a significant impact on the overall cost of the IPO.

By plotting the change in the stock price and the underwriter discounts rate, it seems that the relationship for the selected stock is not really clear:

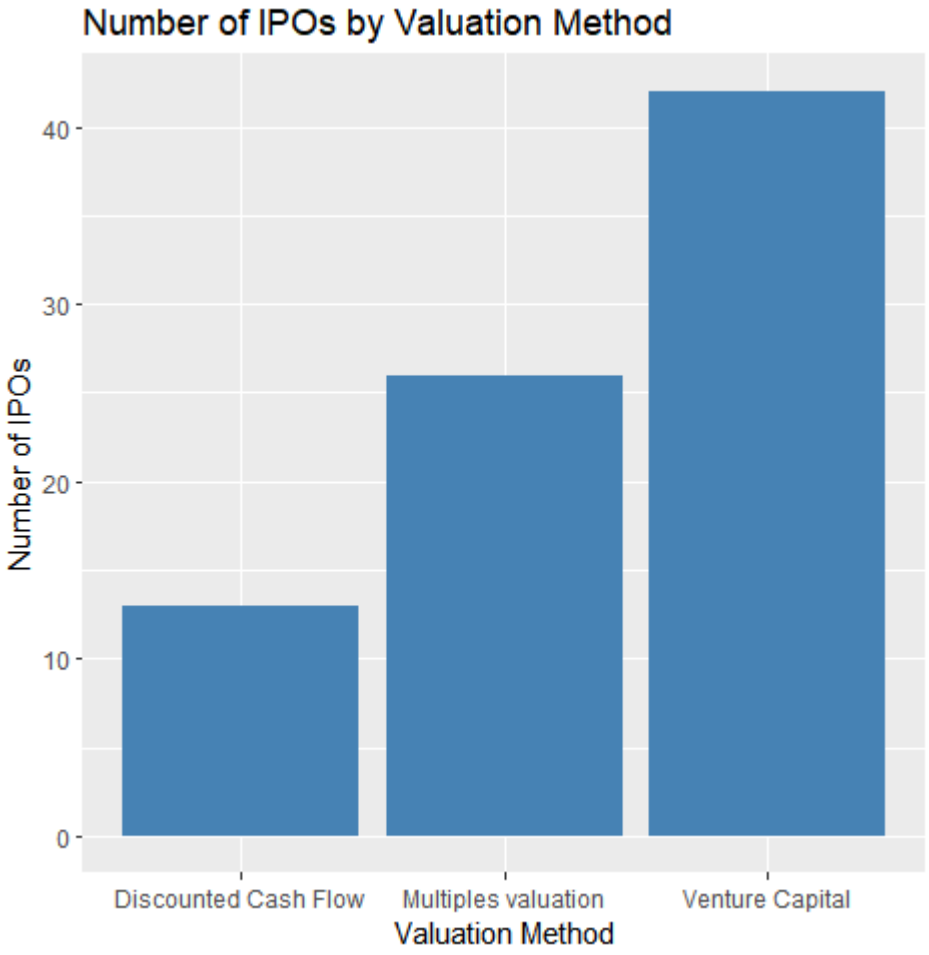


Indeed, the distribution of the change in the stock price after one year does not appear that it has a linear relationship with the discount rate received by the underwriter. However, this is

just an intuition, and it has to be confirmed by further analysis done in the following part.

8.3 Valuation Analysis

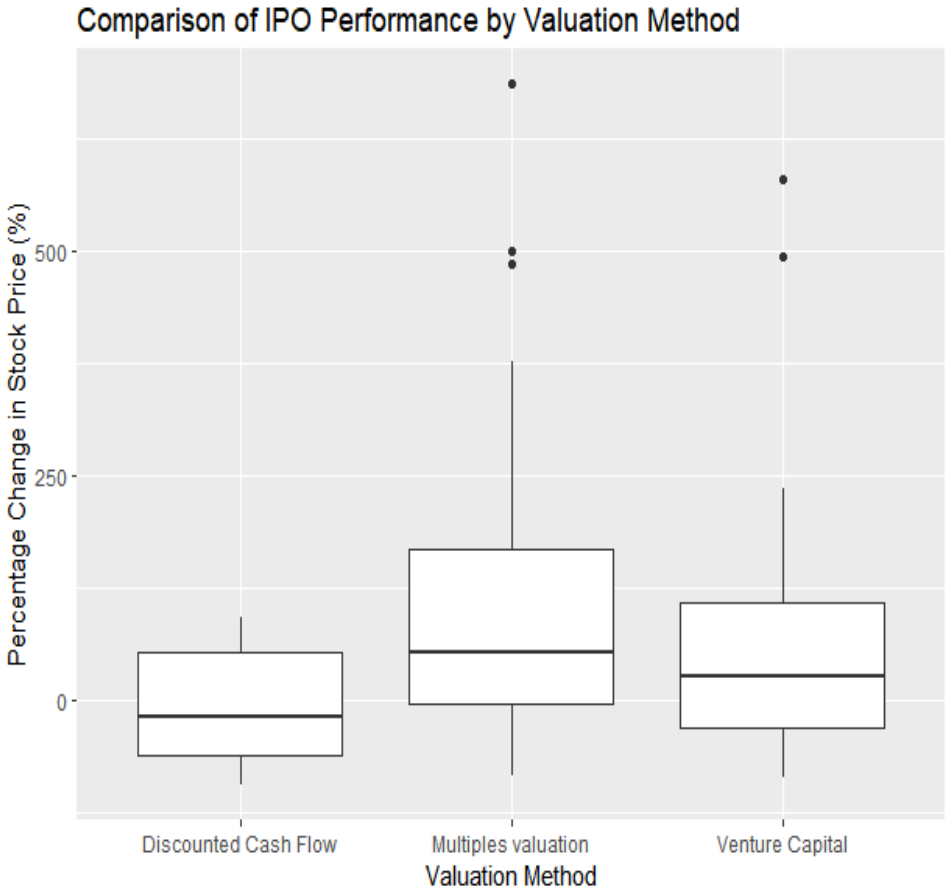
Regarding the analysis of the valuation methods used in our dataset, we can see that the distribution is quite disparate. Indeed, as we can see on this graph:



The discounted cash flow method is the least used method by professional analysts in the valuation of startups in the biotech and pharmaceutical industry. While Venture Capital methods are the most used. Venture Capital methods include all the methods previously mentioned in the specific valuation methods for start-ups. In this broad category, we find most often derivatives of the Berkus model, derivatives of the first chicago method and especially option pricing models.

Based on the 3 main valuation categories, here is a boxplot of the evolution of a share price

according to the methods used:



From a first view, it can therefore be said that the discounted cash flow method is the method that most overvalues the share price at the IPO of a company in its start-up phase that operates in the health care field. Indeed, with a negative median, one can therefore consider that most of the companies in the dataset of this work valued with the DCF method have a negative return within a year. While the multiple valuation method shows the opposite. Almost all companies down to the third quartile have a positive return with even outliers outperforming by as much as x7 in one year from their initial IPO value. Overall, regardless of the valuation method used, in our dataset, the median change in share price after one year of going public is 16% with an average of 68% which is of course driven upwards by the large outliers which greatly outperform.

IX. Results

The primary focus of this chapter was to clarify whether and how the underwriter discount rate and/or method of valuation affects the extent to which the startup's stock is overvalued or undervalued at startup of the IPO. An analytical approach was used, which combined traditional statistical methods with new machine learning techniques

The cornerstone of the analysis was the conduct of three separate linear regressions. Each regression was conducted to examine the relationship between IPO stock price and price one year later, with various independent variables: discount rate, valuation method, and a combination of both measured three methods of valuation: Discounted Cash Flow, the multiples method, and the start-up valuation method. These methods are commonly used in practice and therefore provide a useful and relevant framework for research.

Machine learning methods were utilized concurrently to explore potential correlations between the variables in more detail. This method's main objective was to use machine learning to identify complex, non-linear relationships that conventional regression algorithms could have difficulty identifying.

9.1 Linear regressions

A linear regression is a statistical analysis which aims to establish a relationship between a dependent variable and one or more independent variables. The aim of this analysis is to find the straight line that best fits the observations. This method can be particularly useful for understanding whether certain factors influence others. In this way, we can quantify the strength of the relationship between the independent variables (in this case, the share price at the IPO, the valuation method and/or the underwriter's discount rate) and the independent variable (the share price one year after the IPO).

In our case, we will mainly be looking at the p-value of the independent variables. If the p-value is below 0.05, the variable becomes statistically significant. This means that there is less than a 5% probability that the results observed are due to chance if the null hypothesis (the hypothesis which assumes that there is no relationship between the variables) is true. Indicating that there is indeed a link between the independent and dependent variables.

for each model used, we'll base ourselves on the R output of these linear regressions. Here, then, is the significance of the various statistical data that these outputs can have:

- **Coefficient:** the coefficient in linear regression is the value that multiplies each independent variable. The most important thing here is the sign these coefficients take, as it indicates the directness of the relationship between the dependent and independent variables. If the sign is positive, it means that when the independent variable increases, the dependent variable also increases, and vice versa when the sign is negative.

- **Intercept:** the intercept indicates a constant where the linear regression function intercepts the y-axis. This also means that when all independent variables are 0, the dependent variable is exactly equal to the intercept.

- **P-values (Pr(>|t|):** The p-value is used to determine whether a variable or model is statistically significant. When the p-value is above a certain threshold (often 0.05), the null hypothesis that the variable or model is statistically significant cannot be rejected.

- **R-squared and Adjusted R-squared:** The R-squared measures the proportion of the dependent variable that can be attributed to the independent variable. In other words, it measures how strong the relationship between the model and the dependent variable is. Adjusted R-squared is an improvement on R-squared in that it takes into account the number of dependent variables in its calculation.

Model 1: Price During IPO and Valuation Method

```
lm(formula = Valuation_Data$price_1_year_after_IPO ~ Valuation_Data$Price_per_Share +
    Valuation_Data$Valuation_Method)

Residuals:
    Min      1Q  Median      3Q     Max
-1.1768 -0.5781 -0.1730  0.2865  3.2526

Coefficients:
                                                 Estimate Std. Error t value Pr(>|t|)
(Intercept)                                      -0.49684    0.23882  -2.080   0.0408 *
Valuation_Data$Price_per_Share                    0.48560    0.09764   4.973  3.9e-06 ***
Valuation_Data$Valuation_MethodMultiples valuation  0.70417    0.29230   2.409   0.0184 *
Valuation_Data$Valuation_MethodVenture Capital     0.52229    0.27435   1.904   0.0407 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8601 on 77 degrees of freedom
Multiple R-squared:  0.2879, Adjusted R-squared:  0.2602
F-statistic: 10.38 on 3 and 77 DF,  p-value: 8.208e-06
```

The R-squared value of 28.79% indicates that approximately 28.79% of the variability in the stock price one year after the IPO for the analyzed companies can be explained by the IPO price and the valuation method used. The rest of the explanatory factors are not to be found in this model. These factors may be intrinsic to the company or external to it, such as the macroeconomy.

The significant p-value for the F-statistic (10.38) provides strong evidence against the null hypothesis which suggests that all coefficients in the model are zero. It suggests that the model with these predictors (IPO price and valuation method) performs significantly better than an intercept-only model. In addition, the p-value of each variable is significant. We can therefore state that there is a statistical link between the valuation method and the share price one year after the IPO.

In terms of the valuation method, compared to DCF, the base category, Multiples valuation and Venture Capital methods tend to increase the stock price one year after IPO by 0.70417 and 0.52229 units respectively, all else being equal.

The p-values of each of the dependent variables indicate that the valuation method used does have an impact on the stock price after one year. Indeed, all the dependent variables are statistically significant with all the p-values being below 0.05. Specifically, the Multiples valuation and Venture Capital methods have a stronger positive effect compared to DCF. This

may be explained by the fact that the discounted cash flow method may be considered the least accurate according to theory. In fact, valuation methods specific to start-ups are much better suited to the types of company analyzed in this master's thesis. What's more, when analyzing start-ups that go public, the multiples method also becomes much more suitable, as we can find similar companies that have gone public within a reasonable timeframe. This makes the DCF a totally obsolete method, due to the complexity of cashflow forecasting, which can be hazardous over time.

Model 2: Price During IPO and Underwriter Discount Rate

```
Call:
lm(formula = Valuation_Data$price_1_year_after_IPO ~ Valuation_Data$Price_per_Share +
    Valuation_Data$Ratio_underwriter)

Residuals:
    Min      1Q  Median      3Q     Max
-1.2386 -0.6076 -0.2519  0.2496  3.2849

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                       0.3704     1.7268   0.214    0.831
Valuation_Data$Price_per_Share    0.4864     0.1002   4.855 6.07e-06 ***
Valuation_Data$Ratio_underwriter -5.3867    25.0752  -0.215    0.830
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8864 on 78 degrees of freedom
Multiple R-squared:  0.234,  Adjusted R-squared:  0.2143
F-statistic: 11.91 on 2 and 78 DF,  p-value: 3.06e-05
```

The R-squared value is 23.4%, suggesting this model explains less of the variability in the one-year price compared to the first model. This indicates the underwriter discount rate doesn't contribute as much to the explanation of the variance as the valuation method does in Model 1.

The F-statistic is 11.91 with a very small p-value, indicating a good overall fit of the model. The significant coefficient for the IPO price confirms its significant effect. However, the non-significant effect of the underwriter discount rate suggests it doesn't contribute much to the model, and the stock price one year after the IPO doesn't significantly depend on it.

This result can be explained theoretically. In fact, underwriter discounts are standardized in the industry, which means that some companies, in order to raise more money, demand a higher value from the underwriter in exchange for a higher discount percentage. What's more, assuming that the market is more or less efficient to some degree, investors will become aware

of the overvaluation, and so either the IPO will not be completed, or the share price will adapt to return to a more tolerable level.

Model 3: Price During IPO, Valuation Method, and Underwriter Discount Rate

```
Call:
lm(formula = Valuation_Data$price_1_year_after_IPO ~ Valuation_Data$Price_per_Share +
    Valuation_Data$Valuation_Method + Valuation_Data$Ratio_underwriter)

Residuals:
    Min      1Q  Median      3Q     Max
-1.1640 -0.5935 -0.2014  0.3104  3.2758

Coefficients:
                                                 Estimate Std. Error t value Pr(>|t|)
(Intercept)                                       0.94827    1.69357   0.560   0.5772
Valuation_Data$Price_per_Share                    0.49790    0.09884   5.037  3.1e-06 ***
Valuation_Data$Valuation_MethodMultiples valuation  0.76836    0.30212   2.543   0.0130 *
Valuation_Data$Valuation_MethodVenture Capital    0.57755    0.28219   2.047   0.0441 *
Valuation_Data$Ratio_underwriter                -21.73543   25.21687  -0.862   0.3914
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8616 on 76 degrees of freedom
Multiple R-squared:  0.2948, Adjusted R-squared:  0.2577
F-statistic: 7.943 on 4 and 76 DF,  p-value: 2.098e-05
```

The R-squared value is the highest among all three models (29.48%), indicating that combining both predictors give a better fit than either alone. However, the Adjusted R-squared is below the one in the first model. It means that the better fit is just done by adding more independent variables and not by adding variables that gives effectively information.

The F-statistic is 7.943, again with a very small p-value, indicating a good overall fit of the model. The significant coefficients for the IPO price and both valuation methods suggest these are the crucial factors explaining the variability in the one-year stock price.

The underwriter discount rate is still not statistically significant on the stock price a year after the IPO, even when accounting for the IPO price and valuation methodology. It implies that the underwriter discount rate might not be a crucial consideration when projecting the company's future stock price.

These models imply that the underwriter discount rate does not greatly affect the price of a stock one year after its IPO, but the IPO price and valuation method do.

Model	R-Squared	Adjusted R-Squared	Valuation method significance	Underwriter discount significance	Model significance
1	0.2879	0.2602	Significant	N/A	Significant
2	0.2340	0.2143	N/A	Not significant	Significant
3	0.2948	0.2577	Significant	Not significant	Significant

Table 3: Summary of the three models

In conclusion, these models suggest that the valuation method significantly influences the price of a stock one year after its IPO, but the underwriter discount rate does not. This could mean that the underwriter discount rate is not a crucial factor for predicting stock prices one year after the IPO when controlling for IPO price and valuation method.

9.2 Machine Learning

Machine learning is a category of artificial intelligence that uses a system's ability to learn and make decisions from a given database. These capabilities are based on the training of algorithms that can best understand the elements given to it, and from this can categorize new data using the characteristics of those elements. Machine learning perfectly complements linear regression. In fact, unlike linear regression, machine learning enables us to discover relationships between variables that are not just linear, but of any possible degree.

In this section, the analysis model has been simplified in order to provide an interpretable output from the machine learning models. Instead of precisely analyzing the variation between the price of a share at the time of its IPO and its price one year later, the analysis will be based on a binary quantification: 1 if the share rose during its first year and -1 if the share fell during that year. A problem then arose. In the dataset used for this analysis, the number of companies that performed positively outnumbered those that performed negatively. Since the dataset is skewed in one direction, comparing the accuracy of the machine learning models with an accuracy of 50% would be irrelevant. As a first step, therefore, it is essential to run the models on a database containing only the share price at the time of the IPO and the share price after

one year. In this way, we can compare the results obtained by including the discount rate and/or the valuation method to find a link between these and the share performance of a biomedical start-up in its first year on the stock market.

In this master thesis, three different machine learning models are used: Neural Networks, Random Forests, and Support Vector Machines (SVM) are three of the most influential machine learning models in the field of data science. Neural Networks, inspired by the human brain, are a set of algorithms designed to recognize patterns by interpreting sensory data through machine perception, labeling, or clustering raw input into numerical vectors. This model has been instrumental in the advancement of deep learning, contributing significantly to areas such as image and speech recognition (LeCun, Bengio & Hinton, 2015). Random Forests, on the other hand, are an ensemble learning method that operates by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes for classification or mean prediction for regression tasks. This model is known for its robustness and versatility by handling various types of datasets (Breiman, 2001). Lastly, Support Vector Machines (SVM) is a machine learning technique which use a set of supervised learning methods used for classification, regression, and outliers' detection. SVMs are particularly effective in high-dimensional spaces and can be adapted to different decision functions by specifying different Kernel functions, making them a versatile tool in machine learning (Cortes & Vapnik, 1995).

The results obtained are listed in this table. These results were obtained using an accuracy average with a fold of 5 on the total dataset of start-ups:

	Neural Network	Random Forest	SVM
Base model	0.6051471	0.6161765	0.5926471
Underwritter Discount	0.6028824	0.5830882	0.5551471
Valuation Model	0.6529412	0.7147059	0.6544118
Underwritter Discount and Valuation Model	0.6426471	0.6301471	0.6058824

Table 4: the accuracy rate of machine learning models according to parameters

This table shows the performance of the three machine learning models cited before applied to different scenarios to verify the hypothesis: a base model, a model which incorporate the underwriter discount of the IPO, another one incorporating the valuation model used to give the price of the public share at the IPO and one last model which includes both the underwriting discount and the valuation model.

Let's start by discussing the performance of the basic model, which contains only data on the price of a share at the time of the IPO and on the trend in the stock during its first year. Here, most of the models are above 50%, due to the fact that the database used contains more companies whose shares rose in their first year on the market. In addition, we can see that each machine learning model performs similarly, with an accuracy score of around 0.6.

when we add the underwriter discount variable to the analysis, we see a drop in performance on the 3 machine learning models, suggesting that this feature does not make a significant contribution to model performance and may even introduce noise, reducing model accuracy. This suggests that there is no direct link between the performance of a start-up share during its first year on the stock market and the underwriter discount used at the time of the IPO.

In contrast, including the valuation model as a factor significantly improves the performance of all three models. The accuracy of the neural network jumps to 0.65, the random forest model even increases to 0.71, and the accuracy of the SVM model reaches 0.65. These findings suggest that the valuation model used in the IPO process is a key factor in predicting whether a stock will appreciate or depreciate one year later.

When both the underwriter discount and the valuation model are included as features, the model performance decreases slightly compared to the scenario where only the valuation model is considered with the accuracy of the Neural network and random forest models being about 0.64, and the accuracy of the SVM model is 0.61. This also supports the observation that underwriter discounts may introduce noise into the model, reducing its accuracy somewhat.

In summary, based on the supplied data, it seems that the type of valuation model utilized plays a significant role in forecasting whether a stock's value will appreciate or depreciate after the first year. In contrast, the underwriter discount doesn't appear to enhance the prediction capability of the models, and in certain instances, might even hinder their efficiency. These results may suggest that there is a strong link between the valuation method used at the time of the IPO and its performance in its first year, whereas this link seems non-existent for the underwriter. Furthermore,, these results are in line with the findings of the linear regression analysis, reinforcing and confirming the initial indications.

X. Conclusion, Limitations and future Work

To conclude, this master thesis delves into the complex world of statup valuation, focusing particularly on biotech and pharmaceutical startups during their Inition Public Offering (IPO). It examines whether the value pricing method and the financial dependence of the underwriters have an influence on the fair value of the companies' share prices once they go public.

The results of the linear regression analysis strongly suggest that the valuation method has a significant influence on share prices during the first year of a share's market launch. Whereas the underwriter discount appears to have no linear relationship with it.

In order to avoid focusing solely on linear relationships, machine learning models were run on the initial database. These models have the advantage of better capturing the links between 2 variables, whether linear or not, but have the disadvantage of giving us much less information than a regression. In the three machine learning models used, we can see that accuracy increases when the valuation method is included in the model (suggesting a link) and that accuracy decreases when the underwriter discount is included (suggesting that this variable creates noise and is therefore unmatched).

All these results demonstrate that the valuation method influences over- or undervaluation when valuing a startup operating in the biomedical or pharmaceutical field, whereas the financial independence of the underwriter seems to have no infuence.

However, these interpretations need to be treated with caution, since on the one hand, the study sample is rather small, making it impossible to capture the overall trend in the sector. Moreover, all the companies analyzed are traded on US markets, so we can't capture the global trend.

As far as possible future work is concerned, on the one hand, it would be interesting to extend research away from start-ups making an IPO and try to extend it to larger companies operating in a wider range of sectors. On the other hand, it would be interesting to work on the role of subjective factors such as the entrepreneur's vision, leadership style or environmental awareness of a startup on its market performance.

XI. References

After 20 years: Updating the Berkus Method of valuation | BERKONOMICS. (n.d.). Retrieved 16 January 2023, from https://berkonomics.com/?p=2752

Aggarwal, R., Bhagat, S., & Rangan, S. (2009). The Impact of Fundamentals on IPO Valuation. *Financial Management*, *38*(2), 253–284. https://doi.org/10.1111/j.1755-053X.2009.01035.x

Amit, R., Glosten, L., & Muller, E. (1990). Entrepreneurial Ability, Venture Investments, and Risk Sharing. *Management Science*, *36*(10), 1233–1246. https://doi.org/10.1287/mnsc.36.10.1233

Asquith, P., Mikhail, M. B., & Au, A. S. (2005). Information content of equity analyst reports. *Journal of Financial Economics*, *75*(2), 245–282. https://doi.org/10.1016/j.jfineco.2004.01.002

Åstebro, T., & Bernhardt, I. (2003). Start-up financing, owner characteristics, and survival. *Journal of Economics and Business*, *55*(4), 303–319. https://doi.org/10.1016/S0148-6195(03)00029-8

Athanassakos, G., & Kalimipalli, M. (2003). *Analyst Forecast Dispersion and Future Stock Return Volatility*. *42*(1/2), 57–78.

Aulet, W., & Murray, F. E. (2013). A Tale of Two Entrepreneurs: Understanding Differences in the Types of Entrepreneurship in the Economy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2259740

Babiarz, A. (2016). Methods of valuing investment projects used by Venture Capital funds, financed from public funds. *Uniwersytet Ekonomiczny We Wrocławiu*. https://doi.org/10.15611/pn.2016.428.01

Barker, R. (2001). *Determining Value: Valuation Models and Financial Statements*. Pearson Education.

Bertinetti, G., Cavezzali, E., & Rigoni, U. (2006). The Content of Reports on Italian Stocks: Do Evaluation Methods Matter? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.926043

Bhagat, S. (2014). Why do venture capitalists use such high discount rates? *The Journal of Risk Finance*, *15*(1), 94–98. https://doi.org/10.1108/JRF-08-2013-0055

Birley, S., & Westhead, P. (1994). A taxonomy of business start-up reasons and their impact on firm growth and size. *Journal of Business Venturing*, *9*(1), 7–31. https://doi.org/10.1016/0883-9026(94)90024-8

Bonini, S., & Kerl, A. G. (2012). *Subjective Valuation and Target Price Accuracy* (SSRN Scholarly Paper No. 2168856). https://doi.org/10.2139/ssrn.2168856

Bradshaw, M. T. (2011). Analysts' Forecasts: What Do We Know after Decades of Work? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1880339

Breiman, L. (2001). Random Forests. *Machine Learning*, *45*(1), 5–32. https://doi.org/10.1023/A:1010933404324

Carter, R. B., Dark, F. H., & Singh, A. K. (1998). Underwriter Reputation, Initial Returns, and the Long-Run Performance of IPO Stocks. *The Journal of Finance*, *53*(1), 285–311. https://doi.org/10.1111/0022-1082.104624

Chahine, S. (2008). Underpricing versus gross spread: New evidence on the effect of sold shares at the time of IPOs. *Journal of Multinational Financial Management*, *18*(2), 180–196. https://doi.org/10.1016/j.mulfin.2007.08.001

Chen, C. R., & Mohan, N. J. (2002). Underwriter Spread, Underwriter Reputation, and IPO Underpricing: A Simultaneous Equation Analysis. *Journal of Business Finance & Accounting*, *29*(3–4), 521–540. https://doi.org/10.1111/1468-5957.00441

Chen, Y., Wang, S. S., Tong, W. H. S., & Zhu, H. (2017). Economic freedom and IPO underpricing. *Frontiers of Business Research in China*, *11*(1), 20. https://doi.org/10.1186/s11782-017-0019-1

Clement, M. B. (1999). Analyst forecast accuracy: Do ability, resources, and portfolio complexity matter? *Journal of Accounting and Economics*, *27*(3), 285–303.

Cobanoglu, C., & Ongan, S. (2015). Proceedings of the International Interdisciplinary Business and Economics Conference: Volume 3. *University of South Florida (USF) - M3 Publishing*, *12*(2015). https://doi.org/10.5038/2372-5885-v3

Cockayne, D. (2019). What is a startup firm? A methodological and epistemological investigation into research objects in economic geography. *Geoforum*, *107*, 77–87. https://doi.org/10.1016/j.geoforum.2019.10.009

Cortes, C., & Vapnik, V. (1995). Support-vector networks. *Machine Learning*, *20*(3), 273–297. https://doi.org/10.1007/BF00994018

Damodaran, A. (2009a). Valuing Young, Start-Up and Growth Companies: Estimation Issues and Valuation Challenges. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1418687

Damodaran, A. (2009b). *Valuing Young, Start-Up and Growth Companies: Estimation Issues and Valuation Challenges* (SSRN Scholarly Paper No. 1418687). https://doi.org/10.2139/ssrn.1418687

Damodaran on Valuation: Security Analysis for Investment and Corporate Finance, 2nd Edition | Wiley. (n.d.). Wiley.Com. Retrieved 16 January 2023, from https://www.wiley.com/en-us/Damodaran+on+Valuation%3A+Security+Analysis+for+Investment+and+Corporate+Finance%2C+2nd+Edition-p-9780471751212

Darrough, M. N., & Russell, T. (2002). A Positive Model of Earnings Forecasts: Top Down versus Bottom Up. *The Journal of Business*, *75*(1), 127–152. https://doi.org/10.1086/323507

Davila, A., & Foster, G. (2005). Management Accounting Systems Adoption Decisions: Evidence and Performance Implications from Early-Stage/Startup Companies. *The Accounting Review*, *80*(4), 1039–1068. https://doi.org/10.2308/accr.2005.80.4.1039

Demers, E., & Lewellen, K. (2003). The marketing role of IPOs: Evidence from internet stocks. *Journal of Financial Economics*, *68*(3), 413–437.

Demirakos, E. G., Strong, N. C., & Walker, M. (2004). *What Valuation Models Do Analysts Use? 18*(4), 221–240.

Demirakos, E. G., Strong, N. C., & Walker, M. (2010). Does Valuation Model Choice Affect Target Price Accuracy? *European Accounting Review*, *19*(1), 35–72. https://doi.org/10.1080/09638180902990630

Deng, M., Easton, P., & Yeo, J. (2012). Another Look at Equity and Enterprise Valuation Based on Multiples. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1462794

Dimitriou, M. (n.d.). *On Analysts' Valuation Process*.

Disciplined Entrepreneurship: 24 Steps to a Successful Startup | Wiley. (n.d.). Wiley.Com. Retrieved 25 April 2023, from https://www.wiley.com/en-us/Disciplined+Entrepreneurship%3A+24+Steps+to+a+Successful+Startup-p-9781118720813

Do Security Analysts Improve Their Performance with Experience? On JSTOR. (n.d.). Retrieved 13 January 2023, from https://www.jstor.org/stable/2491458

Dolvin, S. D., & Jordan, B. D. (2008). Underpricing, Overhang, and the Cost of Going Public to Preexisting Shareholders. *Journal of Business Finance & Accounting*, *35*(3–4), 434–458. https://doi.org/10.1111/j.1468-5957.2008.02087.x

Dooley, L., Barrett, G., & O'Sullivan, D. (2022). SME OPEN INNOVATION: DIFFERENCES WITHIN THE SIMILAR ACROSS THE R&D INTENSITY SPECTRUM. *International Journal of Innovation Management*, *26*(08), 2250060. https://doi.org/10.1142/S1363919622500608

Duong, H. N., Goyal, A., Kallinterakis, V., & Veeraraghavan, M. (2021). Market manipulation rules and IPO underpricing. *Journal of Corporate Finance*, *67*, 101846. https://doi.org/10.1016/j.jcorpfin.2020.101846

Dusatkova, M. S., & Zinecker, M. (2016a). Valuing start-ups – selected approaches and their modification based on external factors. *Business: Theory and Practice*, *17*(4), Article 4. https://doi.org/10.3846/btp.17.11129

Dusatkova, M. S., & Zinecker, M. (2016b). Valuing start-ups – selected approaches and their modification based on external factors. *Business: Theory and Practice*, *17*(4), Article 4. https://doi.org/10.3846/btp.17.11129

Easterwood, J. C., & Nutt, S. R. (1999). Inefficiency in Analysts' Earnings Forecasts: Systematic Misreaction or Systematic Optimism? *The Journal of Finance*, *54*(5), 1777–1797. https://doi.org/10.1111/0022-1082.00166

Egwakhe, A. J., Abdullahi, A. O., Akande, F. I., & Umukoro, E. J. (2022). Entrepreneurship Education and Business Startup Performance: Are Personal Characteristics a Growth-Catalyst? *International Journal of Academic Research in Business and Social Sciences*, *12*(5), Pages 929-948. https://doi.org/10.6007/IJARBSS/v12-i5/13232

Erkilet, G., Janke, G., & Kasperzak, R. (2022). How valuation approach choice affects financial analysts'

target price accuracy. *Journal of Business Economics*, *92*(5), 741–779. https://doi.org/10.1007/s11573-021-01061-w

Fazekas, B. (2016). Value-Creating Uncertainty – A Real Options Approach in Venture Capital. *Financial Economic Review*. https://www.semanticscholar.org/paper/Value-Creating-Uncertainty-%E2%80%93-A-Real-Options-in-Fazekas/15026a5fbfe50760ee10df5a9d0a8a815e47d5c0

Feld, B., & Mendelson, J. (2019). *Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist*. John Wiley & Sons.

Ferraro, O. (2020). A Brief Overview of the IPO Valuation Methods. *International Journal of Business and Management*, *15*, 41. https://doi.org/10.5539/ijbm.v15n12p41

French, S., & Leyshon, A. (2010). Commentary. *Environment and Planning A: Economy and Space*, *42*(11), 2549–2559. https://doi.org/10.1068/a43421

Gajdica, R., & Byrne, R. (2020). The Effect of Margin and Reserves/Production Ratio on Oil and Gas Transaction Multiples. *Day 2 Tue, October 27, 2020*, D021S007R004. https://doi.org/10.2118/201348-MS

Ge, D., Mahoney, J. M., & Mahoney, J. T. (2005). *New Venture Valuation by Venture Capitalists: An Integrative Approach* [Working Paper]. University of Illinois at Urbana-Champaign, College of Business. https://econpapers.repec.org/paper/eclillbus/05-0124.htm

Granlund, M., & Taipaleenmäki, J. (2005). Management control and controllership in new economy firms—A life cycle perspective. *Management Accounting Research*, *16*(1), 21–57. https://doi.org/10.1016/j.mar.2004.09.003

Habib, M. A., & Ljungqvist, A. P. (2001). Underpricing and Entrepreneurial Wealth Losses in IPOs: Theory and Evidence. *The Review of Financial Studies*, *14*(2), 433–458.

Home. (n.d.). Venionaire Capital. Retrieved 27 April 2023, from https://www.venionaire.com/home/

Hou, L., & Parrilli, D. M. (2009). SME cluster vs. multinational companies: Similarities and differences for tax and competition lawmakers. *International Journal of Private Law*, *2*(4), 400.

https://doi.org/10.1504/IJPL.2009.024480

Hudson, J., & Khazragui, H. F. (2013). Into the valley of death: Research to innovation. *Drug Discovery Today*, *18*(13), 610–613. https://doi.org/10.1016/j.drudis.2013.01.012

Imam, S., Barker, R., & Clubb, C. (2008). The Use of Valuation Models by UK Investment Analysts. *European Accounting Review*, *17*(3), 503–535. https://doi.org/10.1080/09638180802016650

Imam, S., Chan, J., & Shah, S. Z. A. (2013). Equity valuation models and target price accuracy in Europe: Evidence from equity reports. *International Review of Financial Analysis*, *28*, 9–19. https://doi.org/10.1016/j.irfa.2013.02.008

Is the IPO Underwriting Discount Always 7% in an IPO? (2012, June 4). https://www.wilmerhale.com/en/insights/blogs/the-road-to-ipo-legal-and-regulatory-insights-into-going-public/is-the-ipo-underwriting-discount-always-7-in-an-ipo

Jamaani, F., & Alidarous, M. (2019). Review of Theoretical Explanations of IPO Underpricing. *Journal of Accounting, Business and Finance Research*, *6*, 1–18. https://doi.org/10.20448/2002.61.1.18

Keeley, R., Punjabi, S., & Turki, L. (1996). Valuation of Early-Stage Ventures: Option Valuation Models vs. Traditional Approaches. *The Journal of Entrepreneurial Finance*, *5*(2), 115–138. https://doi.org/10.57229/2373-1761.1186

Kollmann, T., Stoeckmann, C., Hensellek, S., & Kensbock, J. (2016). *Deutscher Startup Monitor 2016*.

Kolvereid, L., & Isaksen, E. (2006). New business start-up and subsequent entry into self-employment. *Journal of Business Venturing*, *21*(6), 866–885. https://doi.org/10.1016/j.jbusvent.2005.06.008

Kowlessar, A. F. (2016, December 2). *The Berkus & Risk Factor Summation Pre-Money Valuation Methods*. StartUs Magazine. http://magazine.startus.cc/berkus-risk-factor-summation-pre-money-valuation-methods-explained/

Krishna, A., Agrawal, A., & Choudhary, A. (2016). Predicting the Outcome of Startups: Less Failure, More Success. *2016 IEEE 16th International Conference on Data Mining Workshops (ICDMW)*, 798–805. https://doi.org/10.1109/ICDMW.2016.0118

LE BUSINESS DES BIOTECHNOLOGIES. RÉVOLUTION BIOTECH, BUSINESS MODELS, INVESTISSEMENTS ET PROFITS: Cynthia Robbins-Roth, Dunod, 2001. (Vol. 28, Issue 1, p. 97). (2003). Management International. https://www.proquest.com/abicomplete/docview/195819564/abstract/B215836D80974462PQ/1

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature*, *521*(7553), Article 7553. https://doi.org/10.1038/nature14539

Lee, C. (2003). Choosing the Right Valuation Approach. *AIMR Conference Proceedings*, *2003*, 4–14. https://doi.org/10.2469/cp.v2003.n2.3271

Lie, E., & Lie, H. J. (2002). Multiples Used to Estimate Corporate Value. *Financial Analysts Journal*, *58*(2), 44–54. https://doi.org/10.2469/faj.v58.n2.2522

Lisanti, Y., Luhukay, D., & Mariani, V. (2016). SME's online business strategy to generate profits: Study case: PT IP vs. PT PS. *2016 International Conference on Information Management and Technology (ICIMTech)*, 159–164. https://doi.org/10.1109/ICIMTech.2016.7930322

Ljungqvist, A. (2007). IPO underpricing. *Handbook of Corporate Finance ; Vol. 1*.

Loughran, T., & Ritter, J. (2004). Why Has IPO Underpricing Changed over Time? *Financial Management*, *33*(3), 5–37.

Loughran, T., & Ritter, J. R. (2002). Why Don't Issuers Get Upset About Leaving Money on the Table in IPOs? *The Review of Financial Studies*, *15*(2).

Lowry, M., & Shu, S. (2002). Litigation risk and IPO underpricing. *Journal of Financial Economics*, *65*(3), 309–335. https://doi.org/10.1016/S0304-405X(02)00144-7

Lundholm, R. J. (c2013.). *Equity valuation and analysis with eVal /*. McGraw-Hill Irwin,.

Majercakova, D., & Mittelman, A. (2018). *The Analysis of the Chosen Methods of the Evaluation of Start-Ups on the Specific Case*. 484–490.

Malerba, F., & Orsenigo, L. (2015). The evolution of the pharmaceutical industry. *Business History*, *57*(5), 664–687. https://doi.org/10.1080/00076791.2014.975119

Mann, C. L., & Sanyal, P. (2010). The Financial Structure of Startup Firms: The Role of Assets, Information, and Entrepreneur Characteristics. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1768099

Michaely, R., & Womack, K. L. (1999). Conflict of Interest and the Credibility of Underwriter Analyst Recommendations. *The Review of Financial Studies*, *12*(4), 653–686.

Miller, M. H., & Modigliani, F. (1961). Dividend Policy, Growth, and the Valuation of Shares. *The Journal of Business*, *34*(4), 411–433.

Miloud, T., Aspelund, A., & Cabrol, M. (2012). Startup valuation by venture capitalists: An empirical study. *Venture Capital*, *14*(2–3), 151–174. https://doi.org/10.1080/13691066.2012.667907

mitchellfrom. (2016). *Startup Business Funding Trends 2016*. https://www.semanticscholar.org/paper/Startup-Business-Funding-Trends-2016-mitchellfrom/87135dfee1384e34d7e3454bbbe2556ab5828e72

Montani, D., Gervasio, D., & Pulcini, A. (2020). Startup Company Valuation: The State of Art and Future Trends. *International Business Research*, *13*, 31. https://doi.org/10.5539/ibr.v13n9p31

Moro Visconti, R. (2020). *The Valuation of Digital Intangibles: Technology, Marketing and Internet*. Springer International Publishing. https://doi.org/10.1007/978-3-030-36918-7

Nel, W. S. (2009). Methods of choice in the valuation of ordinary shareholders' equity: Evidence from theory and practice. *Meditari Accountancy Research*, *17*(2), 117–135. https://doi.org/10.1108/10222529200900015

Nissim, D. (2013). Relative valuation of U.S. insurance companies. *Review of Accounting Studies*, *18*(2), 324–359. https://doi.org/10.1007/s11142-012-9213-8

Nurcahyo, R., Akbar, M. I., & Gabriel, D. (2018). Characteristics of startup company and its strategy: Analysis of Indonesia fashion startup companies. *International Journal of Engineering and Technology(UAE)*, *7*, 44–47. https://doi.org/10.14419/ijet.v7i2.34.13908

Nursaadah, M., & Faturohman, T. (2022). *The Application of Risk-Based New Venture Technique for*

Startup Valuation (Case Study: Vee Naturals). *11*, 166–183.

O'brien, P. C. (1988). Analysts' forecasts as earnings expectations. *Journal of Accounting and Economics*, *10*(1), 53–83. https://doi.org/10.1016/0165-4101(88)90023-7

Oliveira, F. B. de, & Zotes, L. P. (2018). Valuation methodologies for business startups: A bibliographical study and survey. *Brazilian Journal of Operations & Production Management*, *15*(1), Article 1. https://doi.org/10.14488/BJOPM.2018.v15.n1.a9

[PDF] Entrepreneurship Education and Business Startup Performance: Are Personal Characteristics a Growth-Catalyst? | Semantic Scholar. (n.d.). Retrieved 25 April 2023, from https://www.semanticscholar.org/paper/Entrepreneurship-Education-and-Business-Startup-Are-Egwakhe-Abdullahi/48dbe7965a6a14f57f9c4a92c108103980f541a9

Penman, S. (2016). *Valuation: The State of the Art*. *17*(1), 3–23. https://doi.org/10.1007/s41464-016-0002-y

Penman, S. H. (2011). *Accounting for value*. Columbia University Press.

Permana, I., Afkar, E., & Augusta, H. (2021). DIFFERENTIAL DIAGNOSIS OF DIGITAL CULTURE IN STARTUP VS NON-STARTUP COMPANIES IN INDONESIA TO DRIVE EMPLOYEE ENGAGEMENT AND DIGITAL MATURITY. *JHSS (JOURNAL OF HUMANITIES AND SOCIAL STUDIES)*, *5*(2), 133–141. https://doi.org/10.33751/jhss.v5i2.3753

Rabier, M. R. (2018). Value is in the Eye of the Beholder: The Relative Valuation Roles of Earnings and Book Value in Merger Pricing. *The Accounting Review*, *93*(1), 335–362. https://doi.org/10.2308/accr-51785

Reis, P., & Augusto, M. (2013). The Terminal Value (TV) Performing in Firm Valuation: The Gap of Literature and Research Agenda. *Journal of Modern Accounting and Auditing*, *9*(12), 1622–1636.

Review of Theoretical Explanations of IPO Underpricing | Journal of Accounting, Business and Finance Research. (n.d.). Retrieved 18 January 2023, from http://scipg.com/index.php/102/article/view/158

Rezende, A. J. (2005). The Relevance of Accounting Information in the Process of Valuation of Companies in the New and Old Economy – An Analysis of Asset Investments and their Effects on the Value

Relevance of Earnings and Book Value. *Brazilian Business Review*, *2*(1), 23–52. https://doi.org/10.15728/bbr.2005.2.1.3

Ritter, J. R. (1987). The costs of going public. *Journal of Financial Economics*, *19*(2), 269–281. https://doi.org/10.1016/0304-405X(87)90005-5

Rubinstein, M. (1976). The Valuation of Uncertain Income Streams and the Pricing of Options. *The Bell Journal of Economics*, *7*(2), 407–425. https://doi.org/10.2307/3003264

Sander, P., & Kõomägi, M. (2007). Valuation of private companies by Estonian private equity and venture capitalists. *Baltic Journal of Management*, *2*(1), 6–19. https://doi.org/10.1108/17465260710720219

Sevilla-Bernardo, J., Sanchez-Robles, B., & Herrador-Alcaide, T. C. (2022). Success Factors of Startups in Research Literature within the Entrepreneurial Ecosystem. *Administrative Sciences*, *12*(3), Article 3. https://doi.org/10.3390/admsci12030102

Skawińska, E., & Zalewski, R. I. (2020). Success Factors of Startups in the EU—A Comparative Study. *Sustainability*, *12*(19), Article 19. https://doi.org/10.3390/su12198200

Soloveychik, K. A., & Sataev, P. A. (2021). *Startups in economics: Definition, essence and characteristics*. *14*(5), 92. https://doi.org/10.18721/JE.14507

S&P 500 Returns since 1957. (n.d.). Retrieved 10 May 2023, from https://www.officialdata.org/us/stocks/s-p-500/1957

Splender, V., & Orlov, A. (2019). A comprehensive assessment of the investment attractiveness of a startup. *Russian Journal of Resources, Conservation and Recycling*, *6*(3). https://doi.org/10.15862/16ECOR319

Stankevičienė, J., & Žinytė, S. (2011). Valuation model of new start-up companies: Lithuanian case. *Business: Theory and Practice*, *12*(4), Article 4. https://doi.org/10.3846/btp.2011.39

Steffens, P. R., & Douglas, E. J. (2007). Valuing technology investments: Use real options thinking but forget real options valuation. *International Journal of Technoentrepreneurship*, *1*(1), 58–77. https://doi.org/10.1504/IJTE.2007.013270

Stowe, J. D., Robinson, T. R., Pinto, J. E., & McLeavey, D. W. (n.d.). *EQUITY ASSET VALUATION*.

Stretcher, R., & Johnson, S. (2011). *Capital structure: Professional management guidance*. *37*(8), 788–804. https://doi.org/10.1108/03074351111146229

Subjective Valuation and Target Price Accuracy by Stefano Bonini, Alexander Gabriel Kerl: SSRN. (n.d.). Retrieved 16 January 2023, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2168856

Talha, M. (n.d.). Philosophy of the Journal. *The Journal of Commercial Biotechnology*. Retrieved 26 April 2023, from https://commercialbiotechnology.com/

Thomas, R., & Gup, B. E. (2009). *The Valuation Handbook: Valuation Techniques from Today's Top Practitioners*. Wiley.

Viebig, J., Varmaz, A., & Poddig, T. (2008). *Equity Valuation: Models from Leading Investment Banks*. John Wiley & Sons.

Yusup, A. K. (2022). Underpricing or Overvaluation? Theoretical Review of Initial Public Offering Phenomenon. *VNU JOURNAL OF ECONOMICS AND BUSINESS*, *2*(4), Article 4. https://doi.org/10.57110/jeb.v2i4.4823

Zhang, L., & Wei, M. (2020). *How analyst recommendations respond to corporate uncertainty caused by investment behavior: Currying favor with management or conflicts of interest from connections*. *10*(3), 243–269. https://doi.org/10.1108/CFRI-05-2019-0046

Демьянова, Е. А. (2018). Актуальные вопросы стоимостной оценки компаний в условиях финтех. *Стратегические решения и риск-менеджмент*, *0*(1), Article 1. https://doi.org/10.17747/2078-8886-2018-1-102-1

XII. Appendix

R Code

```
library(readxl)
library(fastDummies)
library(MASS)
library(caret)
library(nnet)
library(randomForest)
library(e1071)
library(dplyr)
library(MASS)
setwd("C:/Users/benli/OneDrive/Bureau/R mémoire")
Valuation_Data <- read_excel("Valuation startup dataset R.xlsx")
Valuation_Data$`Valuation_Method`<-
factor(Valuation_Data$`Valuation_Method`)
Valuation_Data$Under_Over<-factor(Valuation_Data$Under_Over)
Valuation_Data$`Price_per_Share`<-
as.numeric(Valuation_Data$`Price_per_Share`)
levels(Valuation_Data$`Valuation_Method`)
Valuation_Data[,c(5,11)]<-scale(Valuation_Data[,c(5,11)])
Reg_meth<-
lm(Valuation_Data$`price_1_year_after_IPO`~Valuation_Data$`Price_per_Share`
+Valuation_Data$`Valuation_Method`)
Reg_discount<-
lm(Valuation_Data$`price_1_year_after_IPO`~Valuation_Data$`Price_per_Share`
+Valuation_Data$Ratio_underwriter)
Reg_both<-
lm(Valuation_Data$`price_1_year_after_IPO`~Valuation_Data$`Price_per_Share`
+Valuation_Data$`Valuation_Method`+Valuation_Data$Ratio_underwriter)
Reg_meth2<-
lm(Valuation_Data$Change_in_pourcentage~Valuation_Data$Valuation_Method)
summary(Reg_meth)
summary(Reg_discount)
summary(Reg_both)
summary(Reg_meth2)

plot(Reg_meth)
str(Valuation_Data)
############################## ML regression
Train2<-Valuation_Data[,c(5,14)]#none
Train2<-Valuation_Data[,c(5,6,9,14)]#Both
Train2<-Valuation_Data[,c(5,6,14)]#Meth
Train2<-Valuation_Data[,c(5,9,14)]#Discount
Fold <- createFolds(Train2$Under_Over, k = 5, list=FALSE)
Accuracy_vector<-rep(0,5)
for (i in 1:5){
  validation_cv <- Train2[Fold==i,]
  train_cv <- Train2[Fold!=i,]
  reg<-multinom(Under_Over~.,data = train_cv)
  pred <- predict(reg,validation_cv)
```

```
  Accuracy_vector[i] <-
sum(pred==validation_cv$Under_Over)/nrow(validation_cv)
}
Accuracy_CV <- mean(Accuracy_vector)
Accuracy_CV
############################## ML RF
Fold <- createFolds(Train2$Under_Over, k = 5, list=FALSE)
Accuracy_vector<-rep(0,5)
for (i in 1:5){
  validation_cv <- Train2[Fold==i,]
  train_cv <- Train2[Fold!=i,]
  reg<-randomForest::randomForest(Under_Over~.,data = train_cv,ntree=1000)
  pred <- predict(reg,validation_cv)
  Accuracy_vector[i] <-
sum(pred==validation_cv$Under_Over)/nrow(validation_cv)
}
Accuracy_CV <- mean(Accuracy_vector)
Accuracy_CV
############################## ML SVM
Fold <- createFolds(Train2$Under_Over, k = 5, list=FALSE)
Accuracy_vector<-rep(0,5)
for (i in 1:5){
  validation_cv <- Train2[Fold==i,]
  train_cv <- Train2[Fold!=i,]
  reg<-svm(Under_Over~.,data = train_cv)
  pred <- predict(reg,validation_cv)
  Accuracy_vector[i] <-
sum(pred==validation_cv$Under_Over)/nrow(validation_cv)
}
Accuracy_CV <- mean(Accuracy_vector)
Accuracy_CV
##############################Graph1
ipo_count <- Valuation_Data %>%
  group_by(year = lubridate::year(IPO_Date)) %>%
  summarize(IPOs = n())
ggplot(ipo_count, aes(x = year, y = IPOs)) +
  geom_line() +
  scale_x_continuous(breaks = seq(min(ipo_count$year), max(ipo_count$year),
by = 1)) +
  labs(x = "Year", y = "Number of IPOs", title = "IPO Activity Over Time")
##############################Graph2
ggplot(Valuation_Data, aes(x = `Ratio_underwriter`)) +
  geom_histogram(binwidth = 0.005, fill = "steelblue", color = "white") +
  labs(x = "Underwriter Discount", y = "Frequency", title = "Histogram of
Underwriter Discounts")
##############################Graph3
ggplot(Valuation_Data, aes(x = Valuation_Method, y =
Change_in_pourcentage*100)) +
  geom_boxplot() +
  labs(x = "Valuation Method", y = "Percentage Change in Stock Price (%)",
       title = "Comparison of IPO Performance by Valuation Method")
##############################Graph4
ggplot(Valuation_Data, aes(x = Ratio_underwriter, y =
Change_in_pourcentage*100)) +
  geom_point() +
```

```
  labs(x = "Underwriter Discount (%)", y = "Percentage Change in Stock
Price (%)",
       title = "Relationship Between Underwriter Discount and IPO
Performance")
##############################Graph5
meth_count <- Valuation_Data %>%
  group_by(Valuation_Method) %>%
  summarise(Count = n())
ggplot(meth_count, aes(x = Valuation_Method, y = Count)) +
  geom_bar(stat = "identity", fill = "steelblue") +
  labs(x = "Valuation Method", y = "Number of IPOs", title = "Number of
IPOs by Valuation Method")
```

Abstract :

This master's thesis presents an empirical study on the value creation during the IPO employed for startups operating in the biotech and pharmaceutical sectors. The primary objective is to determine the impact of the value-discounting method and of the underwriter's financial independence on the fair price of these companies' shares when they are first floated on the stock market.

Through an in-depth analysis of recent IPOs of start-ups in the pharmaceutical and biotech sectors, this paper explores the potential effect of the above-mentioned two points on share prices one year after the IPO. By employing a 2-methods approach, the research combines both quantitative and machine learning approaches to gain an overview of the various interactions that all these factors may have.

The results of this work highlight a significant relationship between the selection of the valuation method and the share price after one year. Furthermore, the study also reveals that in our case, the underwriter discount has no correlation with whether or not the share price increases after one year.

In a nutshell, this master’s thesis makes a contribution to our understanding of the valuation process and its implications for the market price of these young small companies.

UNIVERSITÉ CATHOLIQUE DE LOUVAIN
Louvain School of Management
Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve
Boulevard Emile Devreux 6, 6000 Charleroi, Belgique
Chaussée de Binche 151, 7000 Mons, Belgique
www.uclouvain.be/lsm