RELATIONSHIP BETWEEN VENTURE CAPITAL AND THE PERFORMANCE OF THE RUSSELL 2000 STOCK MARKET INDEX

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Abstract

The objective of this paper is to analyse whether there is a relationship between venture capital investment and its past periods with the performance of the Russell 2000 stock index. From this relationship, it can be concluded that venture capital investment in certain industries can benefit both the companies in which it invests and those in which it does not invest due to a spill-over effect.

The paper discusses the context of venture capital, its role in the economy, its main objectives, and its history, all focused on the United States.

To analyse the relationship between venture capital and the Russell 2000, descriptive statistics, and regression analysis with the Finite Distributed Lag (FDL) model are used.

Keywords: Russell 2000, Finite Distributed Lag (FDL) model

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1. Introduction

Venture capital (VC) is a form of financing that specialises in start-up companies that have high growth potential and are in early stages of development. It differs from other traditional sources of funding because it not only provides capital, but also enters the company to provide strategic advice, gives access to a wide network of contacts and experience.

There are several reasons for VCs' impact on today's business landscape. Firstly, VCs have proven to be a key catalyst for innovation. By investing in companies with disruptive ideas and novel technologies, VCs foster the creation of new products and services. It also fosters entrepreneurship by helping to overcome one of the major barriers to entrepreneurship, namely lack of capital and difficulty in raising finance.

Another important aspect is the VC's long-term approach. As a riskier source of funding, VC investors receive a stake in the company in return. As a result, investors are not only interested in short-term financial results, but also in the growth of the company and long-term profitability.

VC affects the entire entrepreneurial ecosystem; its impact reaches all companies, whether they are recipients of funding or not. This is because, by funding these companies, it fosters competition and collaboration in the marketplace. These two factors drive innovation across the industry.

It is for these reasons that VC has become so important in today's business environment, as it fosters innovation, entrepreneurship and generates an impact on the economy.

1.1 General objective of the study

The main objective of this study is to analyse whether VC investment in certain sectors may indirectly benefit in a lagged way the companies operating in these sectors in which VC has not invested. Since we cannot assume that VC has invested in all companies in the Russell 2000, if VC is observed to have a positive effect on the performance of the Russell 2000, it could mean that companies in which VC has not invested may be benefiting.

1.1.1 Secondary objectives

This study also aims to demonstrate how VC drives the US economy by encouraging entrepreneurship and innovation. Also, to analyse the close relationship between the VC and the Russell 2000 stock index, as this index is also partly focused on emerging companies. And finally, to demonstrate the relationship between VC, entrepreneurship, and technology.

1.2 Methodology

In the present study, the regression function is used as the method of analysis. The main reason is because the regression function is a statistical tool that is used to study the relationship between two variables, a dependent variable and one or more explanatory variables.

Using this regression function can help to detect trends or patterns in the data. In this case it serves to analyse how VC as a source of financing can be related to the growth of companies in sectors in which it invests. The quantitative impact of the independent variables on the dependent variable can also be analysed by estimating the regression coefficients.

And finally, the regression function gives us the ability to assess the statistical significance of the results, which will help us determine whether the findings obtained are statistically valid and reliable. This gives us a solid basis for making inferences and decisions based on the results of the regression analysis.

To capture and evaluate the possible influence of a change in the independent variable beyond the time period in which it occurred; the finite distributed lag model is used. It allows to include the time dimension in the analysis.

With this model we can analyse the relationship between the VC's past investments and the current growth of emerging companies in specific sectors, finding possible lagged effects.

1.3 Structure

The structure of this study is divided into 6 chapters. The first is this introduction, which is followed by an analysis of the theoretical framework of VC. The second chapter analyses what VC is, how it works, its internal structure, its importance in the economy and the history of the VC industry itself. Also, in this second chapter the Russell 2000 stock market index is explained as it is related to the regression function.

The third chapter describes the data source used, describes the variables, the lags, the estimation methods and explains in detail the regression model used: the finite distributed lags model. The software used to perform the analysis is also described.

The next chapter presents the data used for the study, including descriptive statistics and relevant graphs, as they provide an initial understanding of the sample and aid interpretation and further analysis. In this fourth chapter also applies the regression model and estimates the coefficients through the Ordinary Least Squares method. To conclude this chapter, the data obtained through the regression are interpreted, analysing the statistical significance and the relationships between the variables.

The fifth chapter discusses the results obtained. A more detailed analysis and interpretation of the results obtained in the previous chapter is made, and possible explanations for these data are discussed.

The last chapter is dedicated to summarising the main results and findings of the study. This sixth chapter also answers the objectives set at the beginning of the research and assesses the relevance and implications of the results.

After this last chapter of conclusions there are the bibliographic references.

2. Venture Capital theorical framework

2.1. How it works

Nowadays small and medium enterprises (SMEs) play focal part in the worldwide economy. This is due to its highlights. SMEs have several advantages over large companies. SME have an easier time detecting and taking advantage of small market niches, faster making decisions, communication is easier, and all the staff know each other.

These factors make SMEs stand out for being flexible, dynamic, and easily adaptable. For these reasons, today SMEs are viewed as one of the critical main thrusts of the financial development and occupation creation. Petkovska, T. (2015) estimate that around 90% of all organizations in the worldwide economy are SMEs.

Due to flexibility and dynamism, it is logical that SMEs can produce innovations, which means productivity and growth. And innovations along with inventions drive the U.S. economy (Zider, B., 1998).

The aim of venture capitalists is this sort of enterprises and the entrepreneurs. The entrepreneur is a person who sets up a business or businesses, taking on financial risks in the hope of profit. Both SMEs and entrepreneurs are very attractive for venture capitalist because they have high growth potential. But on the other hand, these have a significant risk.

Bascha and Walz (2001) show the problems encountered by entrepreneurs to secure funding from traditional sources even though they have creative and innovative ideas and a high economic capacity. This may be due to information asymmetry, uncertainty, or the nature of their assets. Moreover, since these are SMEs, the risk assumed by the institution providing the financing is higher, and therefore the financing will also be more expensive. When these drawbacks arise VC can be a reasonable choice.

The VCs role is especially important in the economy as it is a tool to bring together people from different disciplines with different interests. As Green, Milford B (2011) claim that VC can be connected to diverse topics as corporate finance, leveraged buyouts, pension fund investment, entrepreneurship, business incubators and economic development.

Also, for Kaplan and Stromberg (2001) VC solves a problem of the market economies connecting those who need financing, with those who finance. This financing gap is solved by VC. Firms that were supported by venture capital (VC) now have a big significant role in the U.S. and the global economy like Google, Apple, or Intel.

Venture capitalists are professional investors who tend to focus on the technology and market developments since this is the sector where the most innovation is taking place. When venture capitalists are getting ready to make an investment, they make an effort to get to know the company in depth. Often engage in a variety of activities (Fried V., and R. Hisrich, 1994) such as interview all management team, contact entrepreneur's former business associates, existing outside investors, current customers, potential customers, investigate market value of comparable companies, conduct in-depth review of pro forma financials prepared by company. Fried V., and R. Hisrich (1994) show that all these tasks are performed by more than 84% of the venture capitalists. They take such care at this stage because when an investment is made, it becomes illiquid.

Once the investment is made the investors are likely to continue to work to raise more funds to inject into their portfolio companies. They also take a highly active role in the companies in which they invest, participating in the board of directors helping with their vast experience as investors (Gorman and Sahlman, 1989). In addition to sitting on the board of directors, they often act as mentors, providing strategic advice and contacts that can be useful to the company.

Although we have already seen how the knowledge of investors is indispensable in the early stages of the project, Zider, B. (1998) argue that VC is not essential for the main period of funding the basic innovation.

While in the next step it plays an essential role. This second step is when the enterprises start to commercialize their innovations. The purpose is to put resource in a company in order of making it grow both in size and credibility. The role of the VC in corporate governance is of great importance in this process, usually replacing the former CEO of the company.

When the company has reached this point, an outside corporation could buy it or also the institutional public-equity markets could provide liquidity. This process is guided by investors, giving guidance on the exit decision, such as influencing a company’s initial public offering.

It can be seen in Figure 1 the financing stages of the VC.

Stage 1. In this first stage “Seed Capital”, the leaders of a start-up are looking for investors, even if their company does not yet have any products to offer. The first funding that is obtained is usually used for R&D, or for market research.

Stage 2. This second stage “Start-up Capital” starts after the market analysis, product or service development and the elaboration of a business plan. Now with the first customers, the financing of the business is derived from the hiring of staff and improvement of processes.

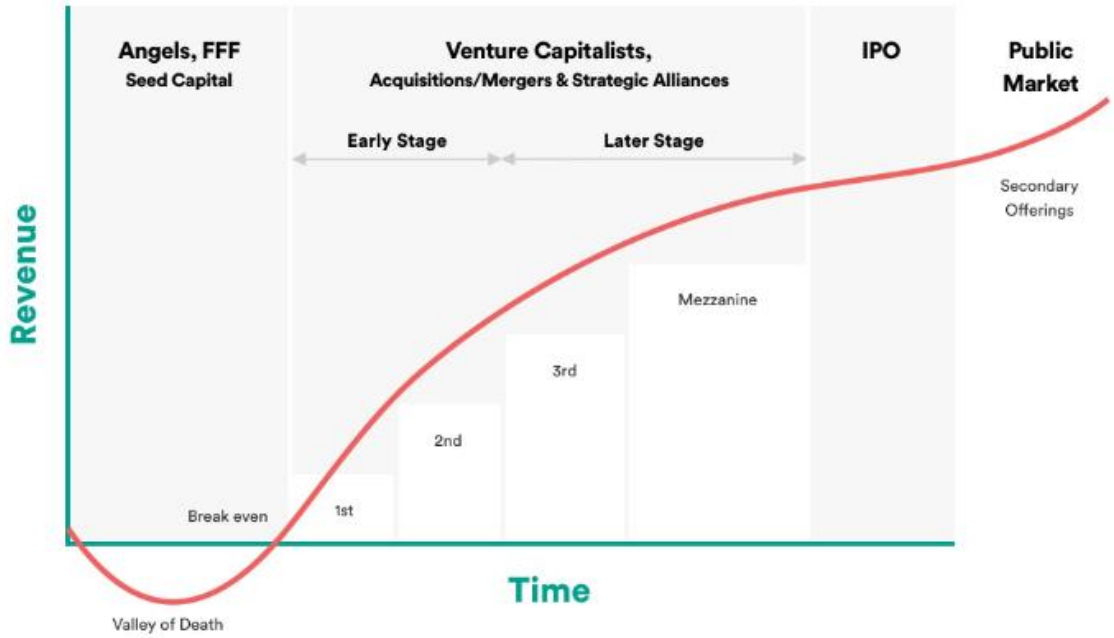
These first two stages are shown in Figure 1 in the Seed Capital part.

Stage 3. This stage is often referred to as the “Early Stage” where funding is much higher than in the previous stages. This funding is invested in manufacturing, production, sales, and marketing facilities. It is at this stage that the company begins to increase its profitability.

Stage 4. This fourth stage is a stage of expansion, where growth is exponential, as the company is earning ample revenue and possibly profits from its products and continues to have VC funding. This allows the company to expand into new markets and develop new products. This stage usually occurs when the company is 2-3 years old.

Stage 5. This stage is often referred to as "Mezzanine", which, once reached, the company can go public. At this stage the funding received can be used for mergers and acquisitions, price reductions or to finance an initial public offering (IPO).

Figure 1. Stages of VC financing



Source: bgf.co.uk

2.2 Relationship between VC and stock market performance

The relationship between VC and stock market performance depends on several factors. VC focuses on financing emerging and high-growth potential companies, which are in the early stages of development, implying a higher risk. And stock market return is the return on investments made in the stock market. It can be influenced by various factors such as economic conditions (GDP, inflation, interest rates, political stability), corporate results, market sentiment, government policies, geopolitical events, etc.

In some cases, VC-backed companies can grow and develop successfully, which can create greater value and potentially positive returns on capital for investors. But, as high-risk, early-stage ventures, there is a chance that they will not achieve the expected results and investors will make a loss.

It is important to note that the relationship between VC investments and stock market returns may vary by industry, stage of company development, market conditions and other specific factors. In addition, returns on VC investments are often measured over the long term, as it takes time for a start-up to grow and become profitable.

Hedman, F. (2019), focuses his study on analysing the relationship between VC and business growth. Contrary to what the existing literature suggests, the empirical results obtained from the analysed country show that there is no significant relationship between VC and the number of high-growth firms. However, a positive relationship is observed between the number of high-growth firms and education, implying that if a government or other organisations want to encourage entrepreneurship, they should initiate policies and programmes that improve education.

Although VC assumes a very important role in funding and supporting start-ups, Hedman, F. (2019) suggests other factors such as education to drive entrepreneurial growth.

Pommet, S., (2017) argues that VC financing can have a negative impact on the survival of listed companies in France in the period 1996-2006. She emphasizes the importance of considering the effects that VC can have on the long-term performance of firms.

However, one factor to take into account is the duration of VC investment. According to the study by Pommet, S., the duration of VC investment prior to IPO showed a positive relationship with firm survival times. This suggests that longer periods of time in which the VC participates in the company may be beneficial to the company in the long run. This is why Pommet, S., stresses how important it is to establish a strong and trusting relationship between the company and the VC investor, in order to maintain a longer relationship that can benefit the company.

Because of these factors, the company should carefully study the advantages and disadvantages of a VC fund's participation in the company. Although the VC provides valuable resources to the company, such as funding and expertise, it is in the interest of the entrepreneur to consider the level of VC involvement and the length of time the VC has been involved in the company. In this way, entrepreneurs can make informed decisions about choosing the VC fund that best suits their needs and goals.

Therefore, the empirical results of the Pommet, S. study highlight the importance of considering both the potential negative and positive effects that VC can have on the long-term profitability of companies.

In conclusion, the relationship between VC and stock market performance is complex. According to studies, the education and duration of the VC's investment can affect the survival and growth of a company. But it should not be forgotten that stock market returns are also influenced by other factors and risks, and each investment must be assessed on an individual basis. VC investment decisions require careful analysis and a thorough understanding of the elements that may affect the long-term performance of the company in which the VC has invested.

2.3 US Venture Capital Focus

VC is a specialised form of equity financing that plays an important role in supporting start-ups with growth potential.

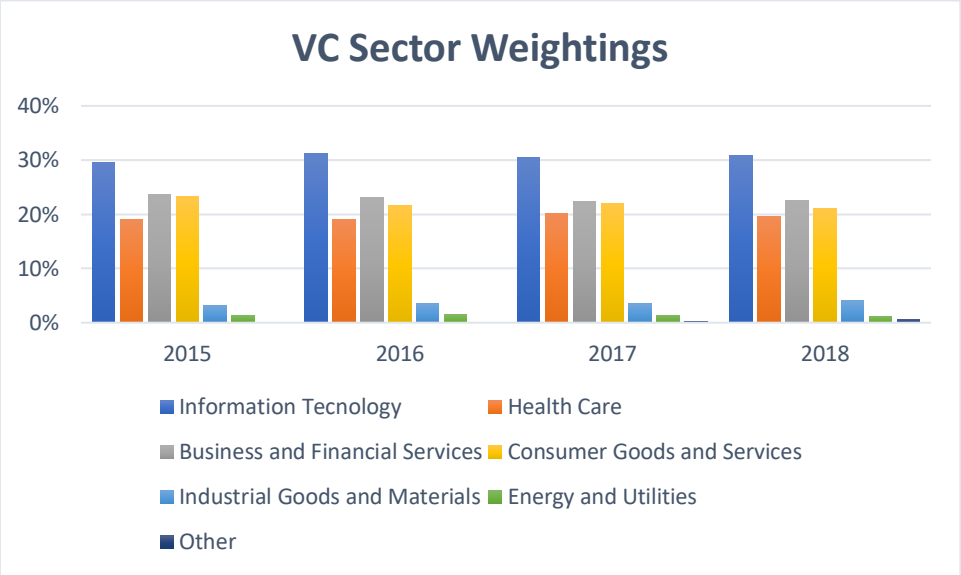
In investment decisions, VC funds tend to focus on sectors that offer significant opportunities for high returns with a significantly small initial investment. According to the OECD, (2016), the most attractive sectors for the type of investment sought by VCs are information technology (ICT) and life sciences. One of the major attractions of both sectors is the high likelihood of highly disruptive innovations, as they are characterised by rapid technological advances and value creation.

On the other hand, industries that generally involve large upfront investments, such as real estate and mining, receive smaller amounts of capital from VCs, as they are projects with longer life cycles and higher levels of risk.

The VC approach in the ICT and life sciences industries reflects a strategic approach, aiming to maximise returns while managing risk.

Figure 2 shows which sectors have been the main focus of VC investment, as measured by deals by industry.

Figure 2. VC Sector Weightings



Source: own elaboration with data from Dow Jones VentureSource

2.4 Relationship between VC and the Russell 2000 index

At this stage we can now discuss the relationship between the VC and the Russell 2000 index to shape the analysis in the following sections.

VC and equity indices have important roles to play in the financial and business landscape. As established in section 2.2, the relationship between VC and stock market returns depends on many factors, including the industry being analysed. Given that VC focuses on the search for high returns through relatively small initial investments with high risk and by focusing investment on specific industries, it is possible that it will affect stock market returns, in particular the Russell 2000 index.

The Russell 2000 index is a stock market index that measures the performance of the 2000 smallest companies in the Russell 3000 index, which is divided into the Russell 2000 and the Russell 1000, which contains the largest companies.

The index was created in 1984 and is managed by the Financial Times Stock Exchange. The FTSE, now known as the FTSE Russell Group, is a British financial institution that provides indices of international financial markets.

The Russell 2000 serves as an indicator of how US small caps are performing, which also provides information on how the overall economy is performing.

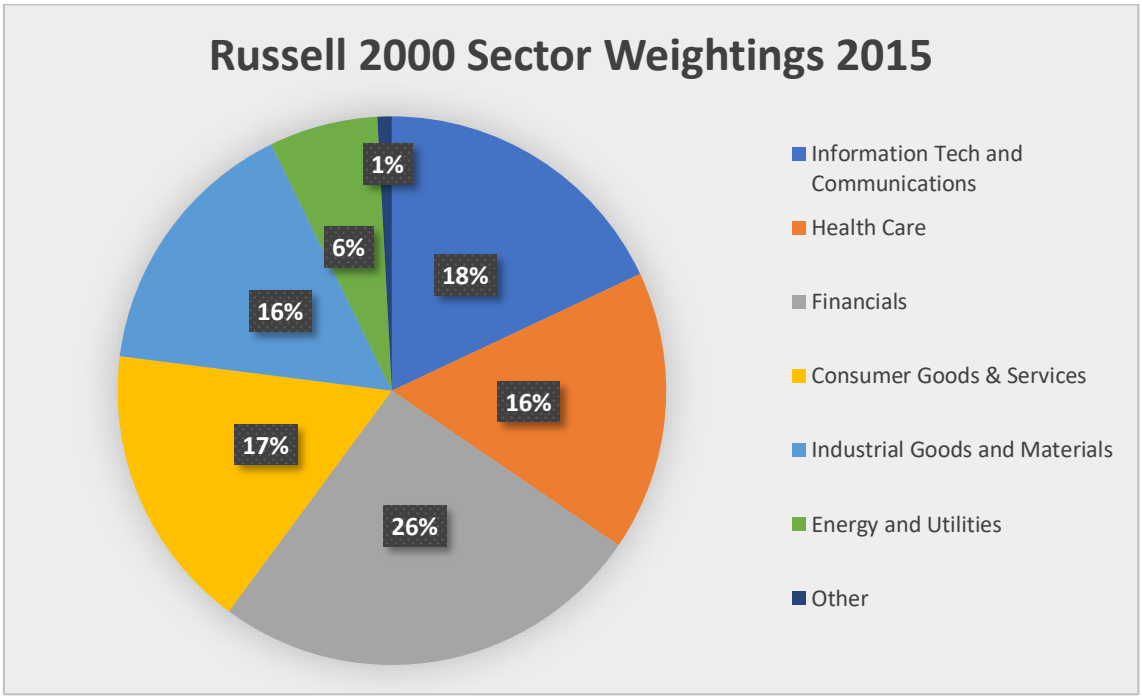
The main characteristics of the Russell 2000 are:

- Higher growth potential: being smaller companies they have higher growth potential than larger companies.
- Smaller and more volatile companies: being smaller companies there is usually more uncertainty and dangers surrounding the company, so they are much more volatile than large companies.
- More diversified: as it is made up of 2000 companies, it is more diversified than indices such as the S&P 500, which only contains 500.

The relationship between the VC and the Russell 2000 index could be very interesting, since if a significant and positive relationship is established between the two variables, it would suggest that VC investments in small companies could have a positive impact on the returns of the index. Also important is the sectors in which the VC focuses its investment and which sectors have the highest weighting within the Russell 2000 index.

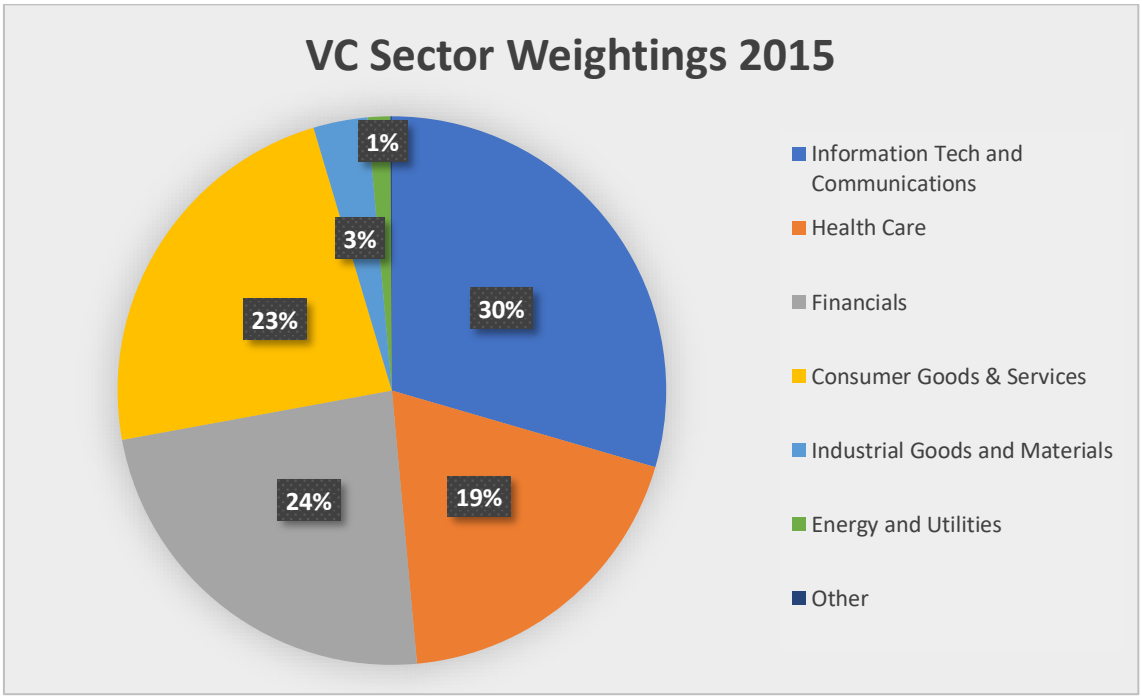
The following is a comparison of the weight of certain industries in both VC investment and the Russell 2000 in 2015 and 2018, as the evolution and similarity of the weights can be seen by looking at these two years. We will also compare the performance of the industries with the highest weights on both sides. The data available for this comparison has been obtained from Dow Jones VentureSource and Siblisresearch.

Figure 3. Russell 2000 Sector Weightings 2015



Own elaboration. Source: siblisresearch.com

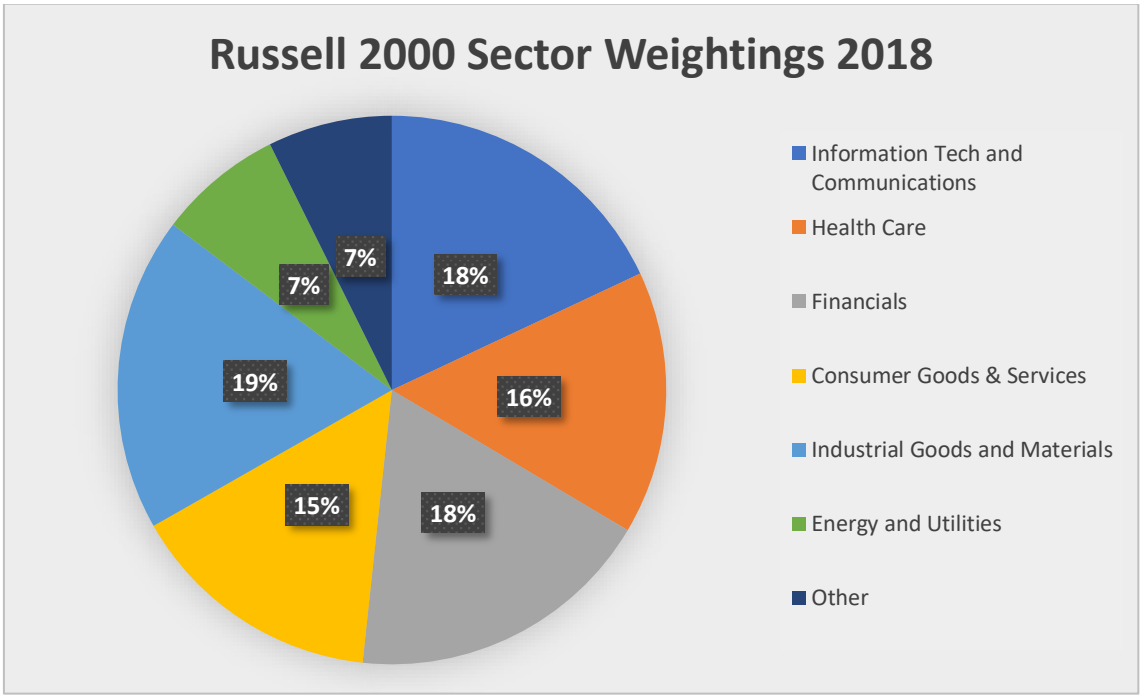
Figure 4. VC Deals by Industry as a percentage in the year 2015



Own elaboration. Source: graphics.wsj.com

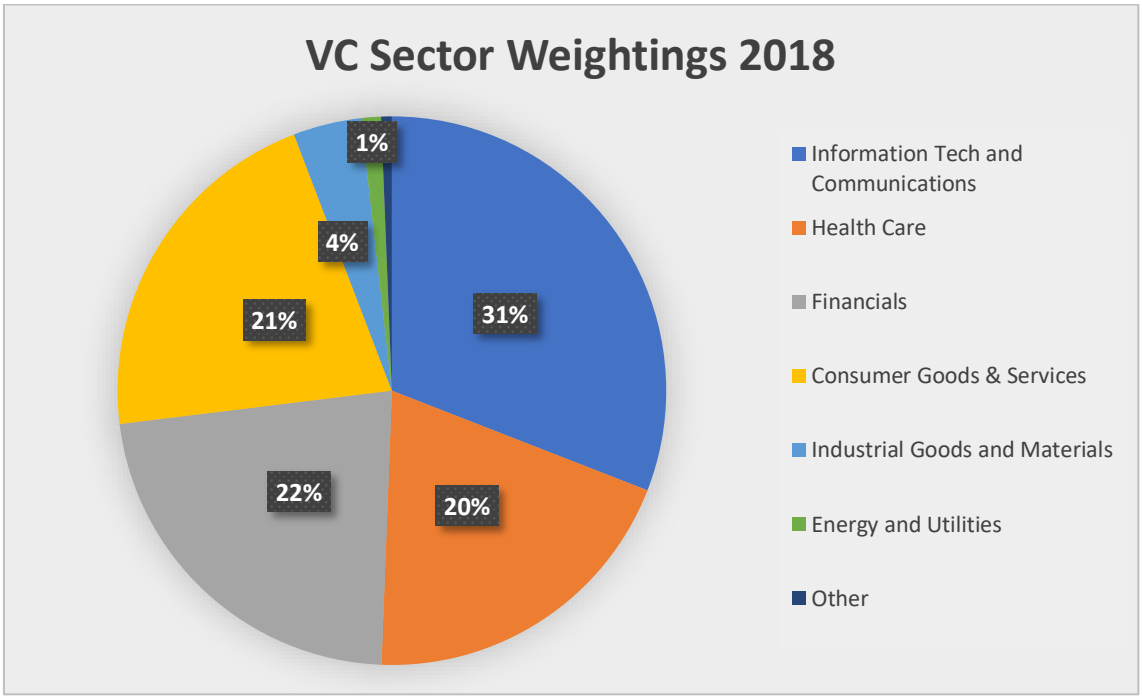
As can be seen in both graphs, there are four predominant sectors that coincide. The sector with the highest share of VC investment is ICT, with 30%, while in the Russell 2000 it ranks second with 18%. Following the ICT industry, the industry encompassing all financial and business services occupies 24% of VC investment and 26% in the Russell 2000. In third place, the consumer goods and materials industry accounts for 23% of VC investment and 17% of the Russell 2000. The last of the most important industries is health care, which accounts for 19% of VC investment and 16% of the stock market index. The goods and materials and energy and utilities industries between them account for only 4% of VC investment, while in the Russell 2000 index they account for 16% and 6% respectively. Finally, other sectors such as real estate have a very small percentage in both. From these graphs it can already be seen how four industries are predominant in both VC investment and the Russell 2000 stock index.

Figure 5. Russell 2000 Sector Weightings 2018



Own elaboration. Source: siblisresearch.com

Figure 6. VC Deals by Industry as a percentage in the year 2018

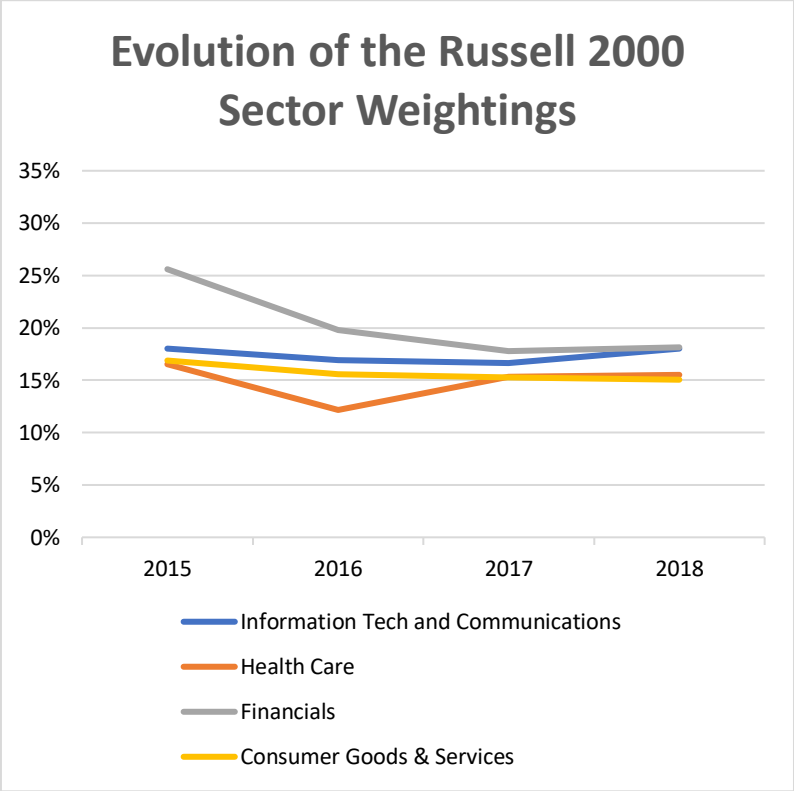


Own elaboration. Source: graphics.wsj.com

In this second comparison, practically all industries continue to have the same importance for VC investment as in the Russell 2000. The decline in the financial and business services industry in the Russell 2000 is notable, falling from 26% to 18% during this period. Another factor to highlight is the importance that the real estate industry gained in the Russell 2000 during these years, reaching a 7% share in the Russell 2000.

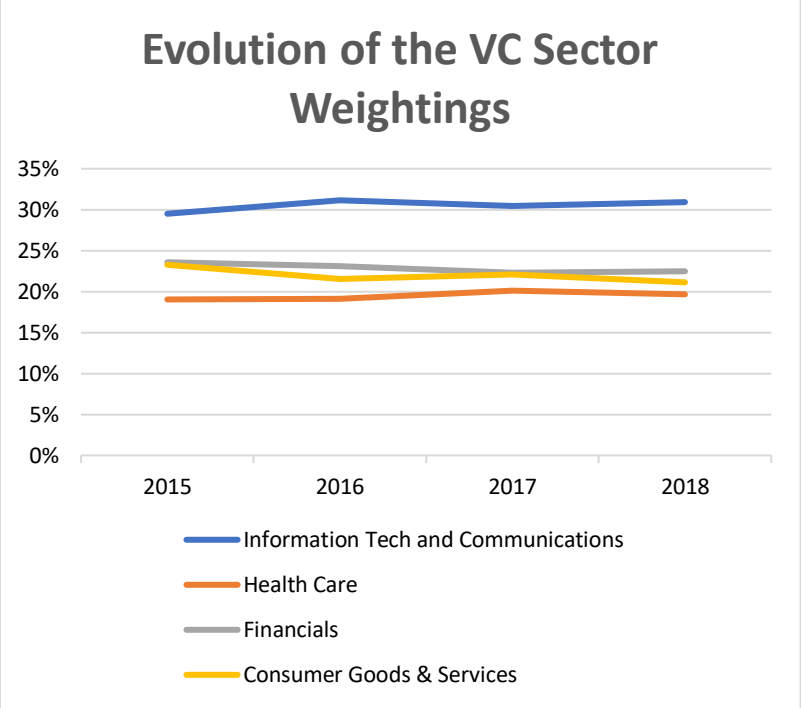
Figures 7 and 8 show the performance of the four sectors with the greatest weight in VC investment and the Russell 2000 from 2015 to 2018.

Figure 7. Evolution of the Russell 2000 Sector Weightings



Own elaboration. Source: siblisresearch.com

Figure 8. Evolution of the VC Sector Weightings



Own elaboration. Source: graphics.wsj.com

The Russell 2000 shows how the financial services industry has declined sharply year on year, while the other three industries have remained relatively stable. On the other hand, in the VC, all sectors are stable and none of them have abrupt variations.

Thanks to the graphs shown, one can see the strong relationship between the VC and the Russell 2000. Both VC and the Russell 2000 index are related to the growth and profitability of companies, as well as being linked to the development and performance of early stage and smaller companies. In addition, both tend to have a strong presence in similar industries. VC focus on high-growth and technology sectors with innovative ideas. The Russell 2000 also tends to include companies in sectors such as technology, healthcare, and financial services.

The Russell 2000 index is considered a key indicator for assessing the performance of smaller capitalisation companies compared to the broader market. By relating VC to the index, it is possible to analyse whether VC investment in certain industries, which are also included in the Russell 2000, may positively affect these industries, and therefore also be benefiting companies in which VC has not invested.

2.5 History in U.S.

This section explains how the contemporary VC industry arose in the U.S. This started happening after the lack of risk capital following the Great Depression. The industry emerged thanks to different initiatives taken by both governments and private actors. 35 years later, the industry was legitimately consolidated and started to be a very useful tool for both innovation and the growth of economies.

King (2011) explains that the VC history is divided into 4 sub-sections. The first one is the historical antecedents and the institutional context. Secondly, the creation of what is considered the first VC company: American Research and Development (ARD). Third, the phase in which the process of legitimising VC begins. Fourth, looks at the explosive but turbulent growth of the industry and its future.

According to King (2011), the beginning of the industry can be traced back to the funds raised by Gutenberg in 1450 for the creation of the printing press. And, for the funds captured in Spain by Christopher Columbus in 1492 by Queen Isabella.

In terms of institutional factors, the drivers of the industry were: the emergence of regional clusters, the organization of development and research systems, the way in which the innovations were financed, e.g., early angel investments or the development of markets, and the shortage of capital due to the Great Depression.

In 1946 the company ARD is founded. It was the first company to carry out this activity. It was founded by 4 major investors: Karl Compton, president of Massachusetts Institute of Technology (MIT), Ralph Flanders, president of the Federal Reserve Bank of Boston, Georges Doriot, Harvard Business School professor, and Merrill Griswold, director of Massachusetts Investors Trust. They focused on making high-risk investments in start-up companies at the time of the Second World War.

The period of legitimisation of the VC lasted from 1960-1979. In this process there were four important events.

The first was the federal legislation approved in 1958 which allowed for a new way of investing in companies, the Small Business Investment Company (SBIC). This new legislation allowed SMEs a new way of borrowing from the government and a less restrictive change in taxation. Many venture capitalists did not like SBIC, as this new form of government funding limited the VC's role of creating value by actively participating in companies.

The second important event was ARD's investment in Digital Equipment Corporation (DEC) in 1957. The initial investment was $70,000. Within 14 years, in 1971, it grew to $355 million. This was the VC industry’s first home run, which made the fund a success with a single investment. This event had a great social impact, as it was seen as a way to get rich quick.

The third event was the creation of a new organisational form for the VC, the Limited Partnership. This new type of organisation in the industry offered several advantages for investing in start-ups, such as benefits were directly to the limited partners or, as a limited partnership, the partners did not fear short-term negative results.

In the late 1960's SBIC was already playing a very important role in the risk capital industry. This is due to the large tax cut for investors and the risk absorbed by the government. However, during the 1970s events took place that changed the landscape, e.g., ARD ceased operations, the 1973 oil shock that led the U.S. into a severe recession, the bankruptcy of many SBICs because they could not pay the interest on their debts.

The fourth event was when due to the shortage of risk capital in the 1970s, the US government adopted two regulatory measures in 1978 to combat this problem. The first

was to decrease the capital benefit rate. The second, and a very important one, was the Employee Retirement Income Security Act (ERISA). This law prevented pension funds from participating severely in risk capital. But they were now allowed to invest up to ten percent of the fund's capital in risk capital.

In the 1980s, the foundations were laid for the internet, which then led to the technology boom. This decade was marked by high prices, due to the oil crisis, and by interest rates that reached 20% in 1981. In 1983 interest rates were reduced and inflation fell to 3%, which led to a boom in VC, also thanks to a process of financial deregulation. In these years, VC increased by a factor of five the money that was managed by the funds (Remedios, A.M., 2020). This also led to an increase in the number of VC funds. These factors led private investors to begin to have greater confidence in technology startups. But these tech companies needed constant injections of liquidity in order to grow over time, so investors did not see returns for quite some time.

But this overconfidence, coupled with the boom in tech startup investment due to exaggerated valuations, caused a large drop in prices and capital invested in these companies. This is why, in those years, the only option for VC funds to make a profit was through Initial Public Offering (IPO).

It is interesting to note the effect of the Dotcom Bubble. In the 1990s through to the 2000s there was a huge growth in the use of the internet and technologies. People's perception of these technologies caused the valuations of technology companies to rise exponentially due to speculation. This can be seen in the Nasdaq index, which went from below 1000 in 1995 to 5000 in 2000 (Hayes, A., 2019). When the bubble burst, the Nasdaq fell by 76.81%, and large companies such as Intel, Cisco and Oracle lost more than 80% of their value.

As a result of the dot-com bubble, VC funds saw their portfolios severely damaged due to their high exposure to technology companies. The VC industry was then overcapitalised with large fundraising which led to a new, faster pace of investment and an increase in the number of companies in the market.

From the 2000s onwards, thanks to the increasing growth of technology, new forms of investment appeared, and the costs of all technological components became cheaper, allowing less capital to be needed to start a company. This growth in technology is particularly focused on software, internet, and digital infrastructures. This set of factors meant that computers and the internet became more accessible to the entire population, which encouraged entrepreneurship, as people had greater access to information.

This period also saw the emergence of new ways in which VCs brought value to companies through services such as marketing, talent sourcing and business development. Before the 2008 financial crisis, the VC industry reached another peak in the amount of capital provided, reaching approximately $230 billion.

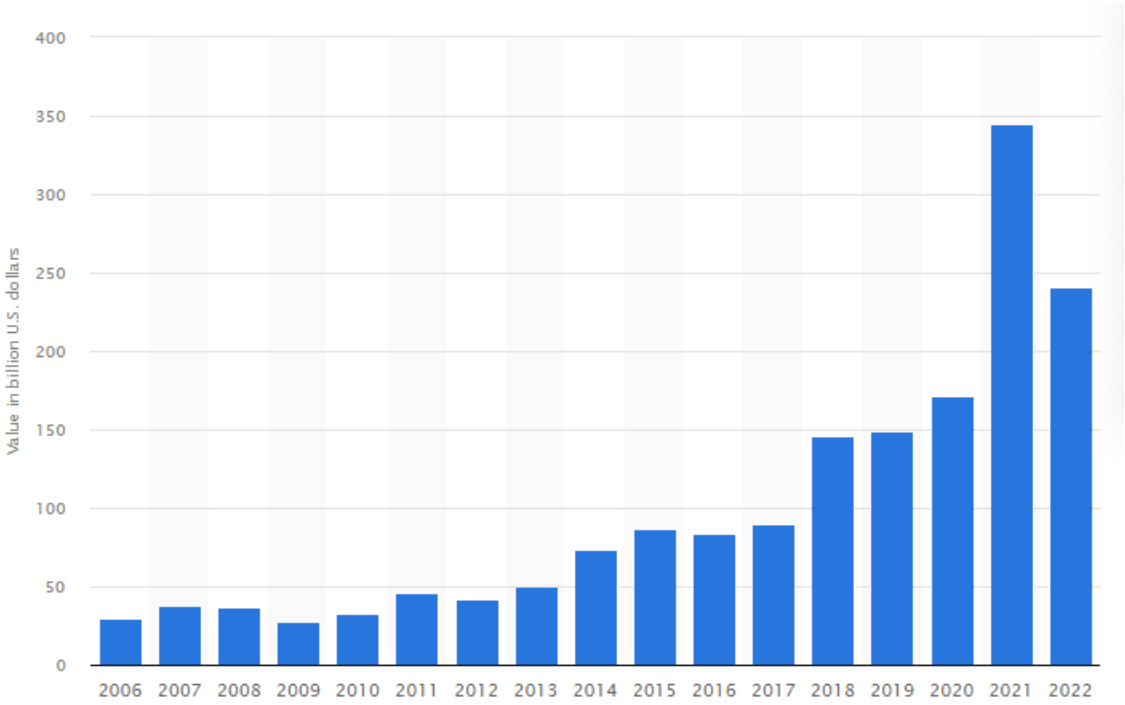
The 2008 financial crisis affected many investment portfolios. In general, it made it very difficult for companies to obtain financing or to cut costs due to the crisis. In VCs (Asenjo, F., 2015), although the number of investments decreased, their portfolios were maintained, and this is because VCs already had large, well-established companies such as Facebook or Groupon.

During the 2010s, new types of VC investments emerged that invested small amounts of capital in a very large number of early-stage companies to balance risk and return. While traditional VCs remain the main source of funding for startups, private equity funds, mutual funds and other non-traditional investors have taken on a role in the later stages.

New initiatives have also been launched to open access to new players in the industry. Venture Forward, Rise of the Rest, All Raise, BLCK VC and Latin VC have struggled to expand VC to other geographic parts of the country, as it was primarily focused on California, Massachusetts and New York. At this time, most of the founders were white, so they also struggled for greater inclusion. This began to create a more inclusive and equitable environment in which the emergence of new ideas and the growth of new companies founded by people from different backgrounds was encouraged.

At the beginning of the 2020 pandemic, the VC industry suffered a slight slowdown, but investors could easily adopt to virtual meetings and continued to look for new startups to invest in. Figure 9 shows the new investment record reached by the VC industry in 2020, only to be surpassed in 2021. It shows the strength of the industry, and that while most economic sectors suffered major downturns, VC managed to adapt and find new opportunities. Among these new opportunities are small start-ups that focused on telemedicine, remote working, etc.

Figure 9. Value of VC investment in the United States from 2006 to 2022



Source: Statista

After the all-time high reached in 2021, the industry is in the process of readjusting in 2022. The industry started the year at 2,900 active companies, $995 billion in assets under management and $2,230 billion in capital available to invest in new start-ups. These three factors allow the industry to be in a stable position to cope with possible adverse events in the economy. With all that has been shown in chapter 2, it has been possible to observe the resilience of the VC industry in difficult times, always maintaining its objective of investing in startups that lead innovation.

3. Methodology

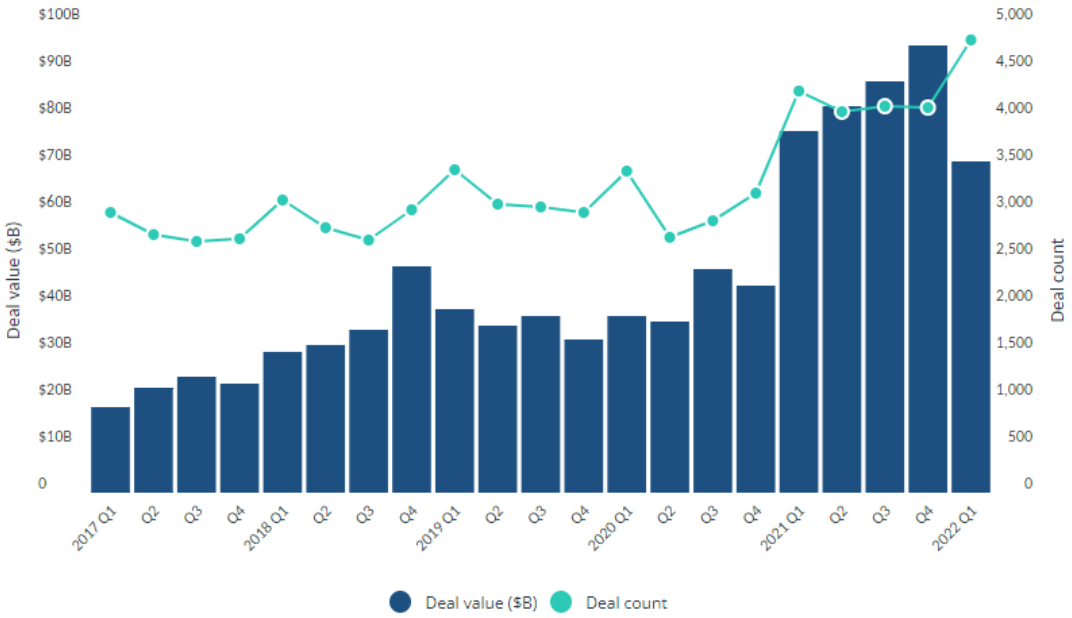
3.1 Description of the data source used and its collection

Various sources have been used to obtain the data for this study. The data was obtained for the period 2017-2021. This period was chosen because it is a period in which both Russell 2000 returns and VC investment have been increasing, and because of the difficulty of finding VC investment data for a long time series in quarters.

One of the variables in the study is the quarterly return variation of the Russell 2000 index. These data have been obtained from the Investing website, which is a financial platform that provides news, market quotes, information on stocks, futures, options, etc. The data provided by the website are the closing price, the opening price, the high and the low, all in days, weeks or months. For the study I have taken the closes of the Russell 2000 in the period from 30 December 2016 to 31 December 2021 on a daily timeframe, and then selected the data with a quarterly timeframe. Although the period to be studied is 2017-2021, to calculate the rate of change for the first period we need the close of the fourth quarter of 2016, which with the data provided by investing is 30 December. Once the monthly closes have been obtained, only those that end quarters have been selected, for example, the data for the close of the first quarter of 2017 is provided on 31 March 2017, that of the second on 30 June 2017, etc.

Obtaining VC investment data has not been that complex. The Pitchbook website offers this data in a graph (Figure 10).

Figure 10. VC deal value from 2017 to Q1 2022 by quarters



Source: Pitchbook)

In this interactive Pitchbook chart you can get the data for each quarter. Once loaded into an Excel spreadsheet, the rate of change is calculated. For this, there is still one missing data, which is the VC investment in the fourth quarter of 2016, which is not provided by Pitchbook. This data has been obtained from KPMG Enterprise's Venture Pulse Q4 2016. Once all the data has been collected, the rate of change is calculated.

3.2 Regression model

A regression model was chosen for the study because it is a statistical tool for exploring causal relationships between variables. It allows to analyse how changes in an independent variable (x) are related to changes in a dependent variable (y).

In this case, as the data source used is a time series, two problems may arise:

1. One time series variable can influence another with time lag.
2. If the variable is nonstationary, a problem known as spurious regression may arise. A non-stationary variable is a variable that has a defined time trend.

Two different models can be used to study time series and are useful for empirical analysis.

- Static models:

In the case of having time series data on two variables, y and x, where y_t and x_t are contemporaneous. The static model that relates y with x is

$$y_t = \beta_0 + \beta_1 x_1 + u_t\ , \qquad t = 1, 2, \dots, n$$

Equation 1

y_t: Dependent variable or variable to be predicted.

x_1: Independent or explanatory variable.

β_0, β_1: Regression coefficients associated with each independent variable.

u_t : Error term capturing variability not explained by the model.

This model implies that a change in x at time t has an immediate effect on y: $\Delta y_t = \beta_1 \Delta x_t$, when $\Delta u_t = 0$.

- Dynamic models:

In contrast to static models, in dynamic models the value of a dependent variable at a point in time depends not only on the value of the explanatory variable at that point in time, but also on the value of that explanatory variable in the past. That is why variables are said to be lagged at some point in time. For this study, the finite distributed lag (FDL) regression model is used. This regression model includes past lags of the independent

variable as additional explanatory variables, to understand the interactions and causal relationships that may arise over time.

A simple model incorporating these dynamic effects:

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \cdots + \beta_n x_{t-n} + u_t$$

Equation 2

y_t: Dependent variable or variable to be predicted.

β_0: Intercept or the constant term representing the base level of Y when all independent variables are equal to zero.

β_1: Coefficient associated with the independent variable x_t without lags.

β_2, β_n: Coefficients of the lags of the independent variable x_t.

x_t, x_{t-1}, x_{t-n}: Values of the independent variable at different lags.

u_t : Error term capturing variability not explained by the model.

In this model it is observed that the effect of the explanatory variable does not occur all at the same time but over several time periods.

In dynamic models, the interpretation of lag coefficients is associated with the concept of multipliers. Starting from Equation 2 with n periods, the coefficient β_1 is the immediate change in the value of the dependent variable when the explanatory variable increases by one unit in the same period of time t. This coefficient β_1 is referred to as the short-term or impact multiplier.

The coefficient β_2 is the change in the value of the dependent variable one period after the unit change in the explanatory variable at a given time, and so on with the other coefficients.

3.2.1 Model construction

As discussed in the first section of this chapter, the data used for the regression model is the quarterly change in the Russell 2000 stock market index and the quarterly change in VC investment in the US. The explanatory variables of the model are the rate of change of VC investment in the U.S. and also the same but with lags.

$$RS_t = \beta_0 + \beta_1 VC_t + \beta_2 VC_{t-1} + \cdots + \beta_n VC_{t-n} + u_t$$

Equation 3

RS: . Rate of change of the Russell 2000 index.

β_0: Intercept or the constant term representing the base level of Y when all independent variables are equal to zero.

β_1: Coefficient associated with the independent variable x_t without lags.

β_2, β_n: Coefficients of the lags of the independent variable x_t.

VC_t : Rate of change of the VC investment.

VC_{t-1}, VC_{t-n} : Rate of change of the VC investment at different lags.

u_t : Error term capturing variability not explained by the model.

The Ordinary Least Squares (OLS) method is used to obtain the estimated values of the coefficients and the error term. The software used to carry out the parameter estimation through the OLS is Gretl.

4. Empirical findings

4.1 Descriptive statistics

Before estimating the parameters through OLS, it is interesting to analyse descriptive statistics that allow us to analyse the variables and obtain a deeper understanding of the data.

A time series graph can be used to visualise the evolution of both variables over time and to identify seasonal patterns, trends, or structural changes in the data.

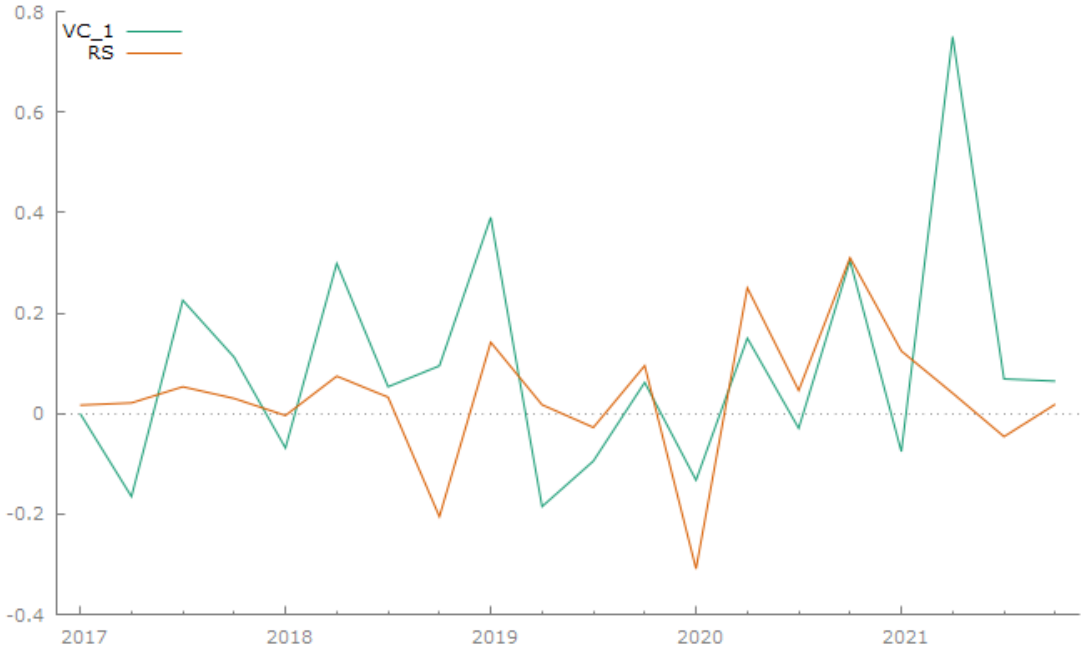
Figure 11. Time series between VC and Russell 2000

Own elaboration. Source: Pitchbook and Investing

In the chart you can see how the variables do not seem to have a relationship over time, as at times like Q4 2018 the VC has a big rise while the Russell 2000 is having a big fall. This is also the case in Q1 2020 or Q3 2020. It is also the other way around, quarters where the Russell 2000 has risen and the VC has fallen, such as in Q1 2020 or Q4 2020.

Since the objective of the study is to analyse how VC investment in the same and previous periods affects the Russell 2000 stock market index and therefore small firms, it is interesting to study a time series graph lagging the VC investment variable by one period.

Figure 12. Time series with the variable VC lagged one period



Own elaboration. source: Pitchbook and Investing

In this second graph it can be seen how the variables are closely related. In the first period when the VC has greater variability and the Russell 2000 is partially constant, there is not much of a relationship. But it can be seen in general from Q2 2018 onwards that both variables have a joint movement. When the VC increases or decreases so does the Russell 2000. You can see very easily from Q4 2019 to Q1 2021 how they practically make the same movements.

Another statistic that can help to analyse this relationship is the correlation coefficient. It can be useful for several reasons, such as providing a quantitative measure of the relationship between two variables and whether it is positive or negative, or indicating whether the relationship is strong or weak.

Table 1. Correlation coefficient between the variables VC and Russell 2000

correlation coefficient	-0,25702053

Own elaboration. source: Pitchbook and Investing

The correlation coefficient between the VC and Russell 2000 variables is -0.2570. This indicates a moderate negative correlation between the two variables. It means that there is a trend as the VC increases the Russell 2000 tends to decrease and vice versa. Being

a moderate correlation implies that the relationship between the variables is not linear and may be influenced by other factors.

Table 2. Correlation coefficient between the variables VC lagged one period and Russell 2000

correlation coefficient	0,36579224

Own elaboration. source: Pitchbook and Investing

In this case, the correlation coefficient is 0.3657, indicating a moderate positive correlation between the two variables. It suggests that there is a moderate linear relationship between VC investment in one period and the Russell 2000 in the next period. An increase in VC investment in one period is associated with an increase in the Russell 2000 in the following period and vice versa. The strength of this correlation is greater than the previous one, indicating that the relationship is more consistent between these variables.

Thanks to the time series graphs and correlation coefficients, the relationship between the variables has been observed. Although they do not have a strong linear relationship, it can be observed that they have a moderate relationship, which can offer an interesting analysis when interpreting the estimators.

4.2 Regression model estimation

At this stage of the work, we will go into the estimation of the parameters of the finite distributed delay model we have proposed. However, before carrying out the estimation, it is crucial to select the appropriate number of delays to be included in the model.

In a time series analysis, the selection of the number of lags is very important, since an inadequate number of lags can lead to an underspecified or over specified model. To select the number of lags we will use the Schwarz criterion (SC) and the corrected R^2 (Gujarati, D. N., & Porter, D. C., 2010).

Table 3. Lag selection: Corrected R2 and Schwarz criterion

	n=1	n=2	n=3	n=4	n=5	n=6	n=7	n=8
corrected R^2	0,054604	-0,007452	-0,086461	-0,194685	0,106852	0,396895	0,332398	0,955168
Schwarz criterion	−17,24498	−12,41204	−7,827046	−3,460218	−5,663368	−9,448275	−7,239780	−44,36927

Following both criteria, the selected number of delays would be equal to 6, since it has the highest R^2 corrected with the minimum Schwarz criterion. Although the model with 8 lags has a very high R^2 a very small Schwarz criterion value cannot be selected as the model sample is small and we would be left with few degrees of freedom.

The model would look like this:

$$RS_t = \beta_0 + \beta_1 VC_t + \beta_2 VC_{t-1} + \beta_3 VC_{t-2} + \beta_4 VC_{t-3} + \beta_5 VC_{t-4} + \beta_6 VC_{t-5} + \beta_7 VC_{t-6} + u_t$$

Equation 4

And estimating by Ordinary Least Squares (OLS).

Table 4. Ordinary Least Squares (OLS) estimation.

```
Model 1: OLS, using observations 2018:3-2021:4 (T = 14)
Dependent variable: RS

             coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------
  const       0.185730     0.0700754     2.650    0.0380  **
  VC         -0.344437     0.172330     -1.999    0.0926  *
  VC_1       -0.102132     0.181669     -0.5622   0.5944
  VC_2       -0.0747842    0.169192     -0.4420   0.6740
  VC_3        0.146273     0.166934      0.8762   0.4146
  VC_4       -0.118753     0.252741     -0.4699   0.6550
  VC_5       -0.929525     0.281892     -3.297    0.0165  **
  VC_6       -0.507492     0.247045     -2.054    0.0857  *

Mean dependent var    0.034917   S.D. dependent var    0.159787
Sum squared resid     0.092391   S.E. of regression    0.124090
R-squared             0.721644   Adjusted R-squared    0.396895
F(7, 6)               2.222161   P-value(F)            0.174926
Log-likelihood        15.28037   Akaike criterion     -14.56073
Schwarz criterion    -9.448275   Hannan-Quinn         -15.03398
rho                  -0.370665   Durbin-Watson         2.695882

Excluding the constant, p-value was highest for variable 4 (VC_2)
```

Own elaboration with Gretl

In the present model, the investment of the VC and its lags explains 72% of the variability of the quarterly rate of change of Russell 2000. The adjusted R^2 of 0.39 indicates that about 39% of the variability can be attributed to the explanatory variables, also considering the number of variables and observations in the model.

β_0 (intercept): The value of the coefficient is 0.18. It implies that when all explanatory variables are zero, the expected value of the quarterly rate of change of the Russell 2000 is 0.18. Moreover, as it has an associated p-value of 0.03, we can conclude that the coefficient is statistically significant at the 0.1 significance level. Since the study sample is small, we work with a significance level of 0.1.

β_1 (VC investment in period t): The value of the coefficient is -0.34, indicating that a 1% quarterly rate of change increase in VC investment at time t is related to a -0.34% decrease in the quarterly rate of change of the Russell 2000. Furthermore, the associated p-value is 0.09 so the coefficient is statistically significant at the 0.1 significance level.

Of the following coefficients, β_4 stands out, as it positively affects the quarterly rate of change of the Russell 2000. A 1% increase in the quarterly rate of change of VC investment increases the quarterly rate of change of the Russell 2000 by 0.14%. Even so, with a p-value of 0.41, the coefficient is not statistically significant.

Then, the coefficients β_6 and β_7 are statistically significant at a significance level of 0.1 with a p-value of 0.01 and 0.08 respectively. They indicate that an increase in the quarterly rate of change of 1% of the VC negatively affects the quarterly rate of change of the Russell 2000 by -0.92% and 0.5% respectively.

The p-value (F) of 0.19 indicates that, overall, the model is not statistically significant at the 0.1 significance level. This suggests that the set of independent variables does not have a significant effect on the dependent variable.

Table 5. Multicollinearity analysis

```
Variance Inflation Factors
Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

          VC     1.495
        VC_1     1.666
        VC_2     1.508
        VC_3     1.524
        VC_4     1.665
        VC_5     2.075
        VC_6     1.587
```

Own elaboration with Gretl

Regarding the possible existence of multicollinearity, the results obtained from the analysis show that the values of the variance inflation factor (VIF) for all explanatory variables are below 10.0. The VIF is a measure that indicates how much the variance of a regression coefficient increases due to collinearity with other variables. In general, values above 10.0 may indicate the presence of a collinearity problem.

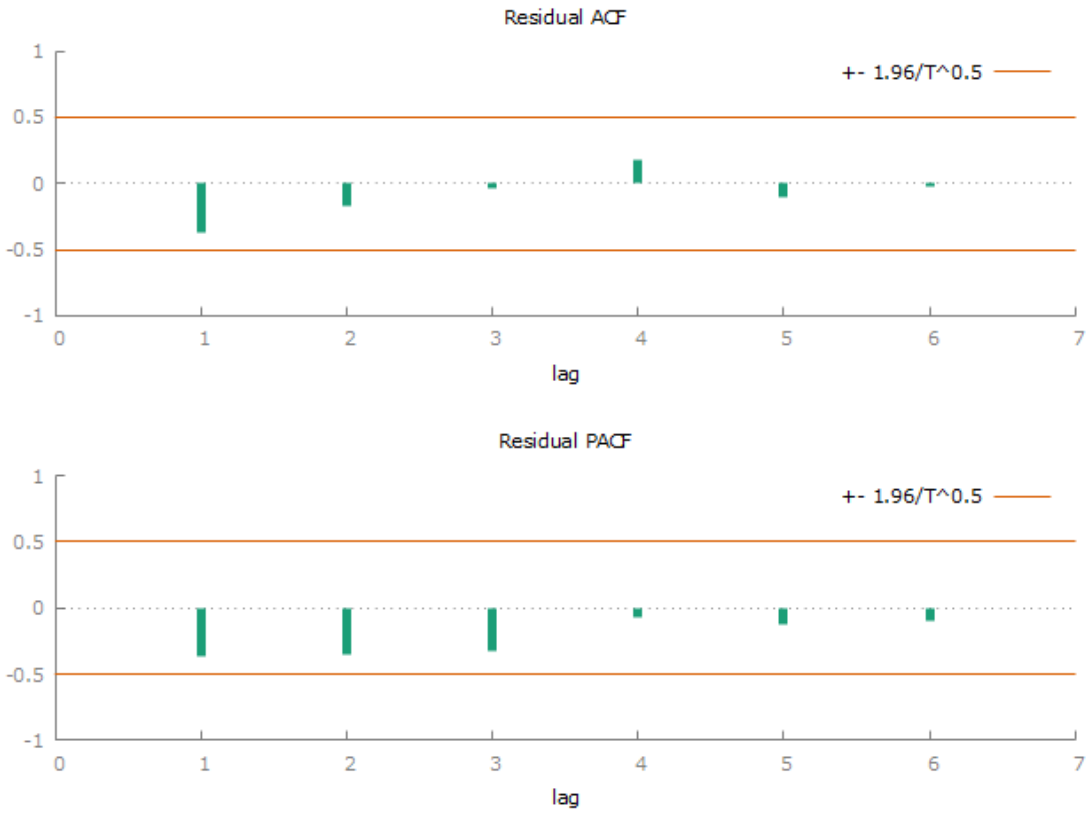
In our case, the VIFs obtained range from 1.495 to 2.075, suggesting that collinearity is not a significant problem in the model. These values are well below the threshold of 10.0, indicating that the relationship between the explanatory variables is reasonably low and that there is no strong linear dependence between them. Since the VIFs are within an acceptable range, we can conclude that there is not enough evidence to claim the presence of multicollinearity in the model. This means that each explanatory variable provides unique information and there is no excessively strong linear relationship between them.

It is important to note that the absence of multicollinearity is desirable in a regression model, as it allows a more accurate interpretation of the estimated coefficients and avoids problems of redundancy in the information. In the absence of significant signs of multicollinearity in this analysis, we can have greater confidence in the estimation and significance of the coefficients of the model.

The Durbin-Watson statistic of 2.69 suggests the presence of positive autocorrelation in the residuals of the model. This implies that there is some serial dependence among the model errors, which could affect the validity of the statistical tests and the inferences made.

Now, to study whether this presence of a slight autocorrelation is significant, a correlogram of residuals in Gretl is shown.

Table 6. Correlogram of residuals



Own elaboration with Gretl

As can be seen in table 6, none of the autocorrelation values are outside the confidence interval, therefore, the theoretical autocorrelation coefficients are statistically equal to 0.

5. Discussion of the results

Even though some variables in the model are not individually significant and the p-value of the F-test indicates that some variables are not jointly significant, there are several arguments to support the validity of the model:

1. Significant variables: although not all variables are individually significant, it is important to keep in mind that it is common to find that only a few variables significantly explain the variability of the dependent variable in regression models. For example, the variables of VC investment at the current time and with 5 and 6 (equivalent to VC investment in Q2 and Q3 of 2020) lag periods have been shown to be significant. It is important to note that the fact that not all variables are individually significant does not invalidate the model. Each variable contributes uniquely and may have a significant effect on the prediction of the dependent variable. Therefore, the presence of significant variables in the model supports its validity and provides us with valuable information about the relationship between the variables involved.

The statistical significance of the variables in the model indicates that there is a relationship between VC and the performance of the Russell 2000. The lagged VC variables act as significant predictors of stock index performance. This implies that VC investment levels in earlier periods have a significant impact on the performance of the stock index in later periods. Furthermore, the fact that the VC and the Russell 2000 have higher weights in the same industries adds an additional level of validity and relevance to the model.

2. Coefficient of determination: In addition to the significant variables, another important aspect that supports the validity of the model is the coefficient of determination (R^2) and the adjusted coefficient of determination. These measures allow us to assess the model's ability to explain the variability of the dependent variable. With an R^2 of 0.72, it is an indication that the model has a good fit and can capture a significant part of the variability of the dependent variable. Although slightly lower than the R^2, the adjusted R^2 has a value of 0.39, it is still a useful measure to assess the goodness of fit of the model. A high adjusted value suggests that the model is effectively capturing the variability of the Russell 2000, even after considering the complexity of the model.

3. Absence of multicollinearity: The multicollinearity analysis has shown that there is no high linear correlation between the explanatory variables. This means that each variable provides unique information and there is no excessive redundancy in the information provided by the variables. The absence of multicollinearity allows a more accurate interpretation of the estimated coefficients and avoids problems of redundancy in the information.

4. Absence of autocorrelation in the residuals: The analysis of autocorrelation in the residuals has shown that there are no systematic patterns of time dependence in the model errors. This indicates that the model has no autocorrelation problems, which is important to ensure that the errors are independent and uncorrelated with each other.

5. Time series charts: Time series charts also demonstrate the relationship between the VC and Russell 2000. Although they do not have a joint movement when compared over the same periods, lagging the VC investment variable by one period they have a very similar movement which shows a relationship.

6. Theoretical relevance: While statistical tests are important, it is also relevant to consider the theoretical and contextual significance of the variables included in the model. If the variables selected have strong theoretical support and are considered relevant to explain the phenomenon under study, this can support the validity of the model even if some variables are not significant.

Although in section 2.2, Hedman, F. (2019) and Pommet, S., (2017) cannot demonstrate that there is a relationship between VC and stock market returns, after the analysis performed, it can be confirmed that there is a relationship between VC investment and the Russell 2000 stock market index. In addition, having conducted the study with the lagged VC variable, we can assume that VC investment in past periods has some predictive power over the performance of the Russell 2000. It could also indicate the influence that the performance of the Russell 2000 has on VC investment decisions in future periods.

This model can be useful in several ways. For example, investors and market analysts can use it to anticipate stock market trends based on VC activity. It can also provide valuable information for investment decisions and financial strategies, both for VC firms and investors in the stock market. In addition, the model can help to better understand the relationship between VC and financial markets, which may have wider implications for economics and public policy related to investment and entrepreneurship.

The overlap in the top-weighted industries also suggests that the model may be particularly valuable for investors and analysts who focus on these specific industries. It provides them with a tool that allows them to better understand and predict stock market behaviour in relation to VC investments in these industries. This gives them a strategic advantage in making informed investment decisions and in assessing the potential for growth and success of companies in these industries.

In addition, the interconnectedness between VC and the Russell 2000 in the same industries can have wider implications for the business and financial ecosystem. It indicates a symbiotic relationship between VC-backed start-ups and financial markets. The performance and success of these companies can influence the overall performance of the stock index, and in turn, the performance of the stock index can have an impact on VC investment decision-making in start-ups.

VC investment in certain sectors may indirectly benefit the companies involved in those sectors, even if VC has not specifically invested in them. Below are some ways in which this can happen:

- Spill-over effect: VC investment activity in each sector can generate a spill-over or carry-over effect to other companies in the same sector. This is because VC firms often provide additional support and resources to the companies they invest in, which can help improve their performance and increase their competitiveness. As a result, companies not directly backed by VC in that sector can benefit from a more dynamic and competitive business environment.
- Attracting investors: The presence of successful VC investments in a particular sector may attract the attention of other investors and venture capitalists. These investors may be interested in taking advantage of the growth and profitability opportunities that the sector offers, which may lead to a generalised increase in investment in companies in the sector. This can drive the development and expansion of companies in the sector, even those that do not have direct VC investment.
- Improving the entrepreneurial ecosystem: VC investment in a specific sector can help strengthen and improve the overall entrepreneurial ecosystem. This is because VC firms often bring experience, expertise, and networks in the sector in which they operate. This contribution can benefit all companies in the sector, as it creates a more favourable environment for the exchange of ideas, collaboration, and innovation. In addition, the success of venture-backed

companies can generate greater interest and confidence in the sector, which can attract further investment and growth opportunities for all companies in the sector.

6. Conclusion

The purpose of this study is to analyse whether there is a significant relationship between VC investment and the performance of the Russell 2000 stock index, as both focus on emerging companies, which offer high returns at high risk. It is also a subject that has hardly been researched.

For the analysis of the relationship, we have used both graphs to compare the industries with more weight in both the VC and the Russell 2000, descriptive statistics and a finite distributed lag (FDL) regression model estimated with the Ordinary Least Squares (OLS) method.

During the theoretical framework we have been able to deepen in what the VC is, which are its financing stages, its main target which are the technological companies (ICT) and the health care companies, the relation with the stock market profitability and more concretely with the Russell 2000, the history of the VC in the U.S.

We have also specified the methodology to be used, how the data to be used for the regression were obtained, we have analysed the types of models that exist and we have chosen a dynamic model for its capacity to explain the interactions and causal relationships that may arise over time, and we have specified the model with the variables quarterly rate of change of the Russell 2000 as the dependent variable and the quarterly rate of change of VC investment and its lags as the independent variable.

In the descriptive analysis, a slight linear relationship between the VC with a lagged period and the Russell 2000 can be observed, illustrated by a time series plot and the correlation index.

Finally, the estimation of the model parameters has been carried out using the Ordinary Least Squares method. Although some of the variables have been shown to be non-significant, the model is significant, since it has significant variables, a high coefficient of determination and a moderate adjusted coefficient of determination, absence of multicollinearity and absence of autocorrelation in the residuals.

Since the model is significant, we can assume both that the model can have a predictive value that can be useful for market analysts and investors to anticipate market trends, and that there is a relationship between VC investment and Russell 2000 performance. Therefore, the VC's investment in certain sectors can benefit both the firms in which he has invested, the firms in those sectors in which VC has not invested (spillover effect), and the sector in general due to the attraction of new investors.

Further research could perhaps develop a much more complex model with more variables that could be significant, but it would entail a complexity that is difficult to address in papers such as this one.

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