

A Work Project, presented as part of the requirements for the Award of a Master's degree in Management from the Nova School of Business and Economics.

Venture Capital Investments during COVID-19:

Evidence from the U.S. Market

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## Abstract

This paper studies the impact of Covid-19 on the Venture Capital industry in the United States. Using a sample of 8,802 funding rounds, different univariate analyses and multiple regressions were conducted. The number of investments was not significantly affected, while companies received on average a higher round amount compared to the pre-pandemic period. This effect is mainly driven by later stage investments, leading to the conclusion that financing stages are impacted differently. Finally, the results show that during the crisis, lead Venture Capitalists tend to invest more in early stage companies operating in their core sector within first rounds.

### **Keywords:**

Venture Capital, COVID-19, Pandemic, Healthcare, Core investments, Financing stages

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## 1 Introduction

The outbreak of the Covid-19 pandemic contracted economic activity dramatically and caused an enormous wave of uncertainty that is more similar in magnitude to the Great Depression than the global financial crisis (Baker et al. 2020). Resulting consequences, i.e. lockdowns and voluntary self-isolating, caused a global reduction in GDP, which is expected to be -4.3% for the United States by the end of 2020 (IMF 2020b). Venture capital (henceforth VC) is one of the industries that is strongly affected by GDP growth and pro-cyclically related to it (Romain & La Potterie 2003). During previous crises, VC activities slowed down, leading to increased concerns about funding gaps of innovative young companies (Block & Sandner 2009). VC has built its reputation as a sector that fuels innovation and economic growth over time and is now associated with some of the most influential and fastest-growing companies globally. Measured by the market capitalization in May 2020, seven of the top eight companies had been backed by VCs before going public (Lerner & Nanda 2020). This underlines the resulting threats that a decline in VC activity may have on the economy of a whole nation. Therefore, a question to consider is whether the VC industry in the United States will follow the same downward trends as the economic downturn, caused by the pandemic, as similarly seen in previous crises.

This paper empirically analyses this question for the first six and a half months after Covid-19 was declared a global pandemic. Firstly, the overall impact on the number of funding rounds and the average investment size are analysed. The resulting implications for different financing stages are then examined, whilst finally considering whether the pandemic affects lead VCs investment behaviours towards young companies related to their core sectors.

This paper contributes to the first findings from previous studies that were either published during the very early stage of the crisis (i.e. Howell et al. 2020) or that follow a more qualitative approach (i.e. Gompers et al. 2020).

## 2 Literature Review

### 2.1 Introduction to venture capital

The VC industry has significantly increased its importance as an intermediary in financial markets over the last few decades. VCs provide capital to companies that might have difficulties in raising money through more traditional means of financing, such as bank loans, since these companies are mostly unable to fulfil interest payments on debt obligations (Gompers 1994; Gompers & Lerner 2001). Compared to wealthy individuals (e.g. business angels), VCs invest external capital raised from limited partners, such as pension funds or other institutional investors (Brander, Amit, & Antweiler 2002). In return for their invested capital, VCs receive equity or equity-linked stakes in the privately held company (Gompers & Lerner 2001). Furthermore, they typically get a seat on the board of directors to take an active role in the management of the ventures they fund (Sahlman 1990; Brander, Amit, & Antweiler 2002).

Companies that are financed by VCs can be seen as high-risk but can also be projects that offer high-reward. The companies are mostly characterized as being small, with few tangible assets to warrant as collateral and face the threat of operating losses for many years (Gompers 1994). The majority of these companies work on radical innovations, and thus a significant impact to the development of new innovation and technology in modern industrial economies can be attributed to VCs (Mason 1999; Samila & Sorenson 2011; Nanda & Rhodes-Kropf 2013). Financing radical innovations, however, involves a high level of risk and uncertainty. VCs constantly develop new operating and contracting practices in order to adapt to environments that are characterized by information asymmetries and high uncertainty between agent and principals (Sahlman 1990). The amount of uncertainty is distinguished through different stages of a company. In general, uncertainty is higher for younger companies, making later stage ventures less risky than early stage ventures (Sapienza & Gupta 1994).

## **2.2 General determinants that impact venture capital activities**

In recent years, there has been considerable interest in general determinants that impact VC activities. Within this research, the focus was on different regions such as the United States (Gompers & Lerner 1999), Europe (Schertler 2003; Cherif & Gazdar 2011; Félix, Pires, & Gulamhussen 2012) and the OECD (Romain & La Potterie 2003), as well as globally (Jeng & Wells 2000). Throughout the literature, the analysed variables were predominantly similar (see Table 1 appendices). In order to get an overall impression of the possible determinants, all geographical areas have been included throughout the literature review. It is expected that general determinants also have an impact during a crisis, leading to possible explanations for later findings in the empirical analysis. Due to the focus of this paper, only those that are considered to have a short-term impact will be examined by their findings from earlier studies.

The liquidity of the stock market has a major impact on any VC activity since market liquidity provides investors with a potential exit through an Initial Public Offering (henceforth IPO) (Black & Gilson 1998). Jeng and Wells (2000) consider IPOs as the strongest driver of VC investments; however, the impact differs among financing stages. Early stage financing is not significantly influenced, while later stage financing is positively affected by IPOs (Jeng & Wells 2000; Félix, Pires, & Gulamhussen 2012). This can be explained through the potential returns IPOs offer to VC funds. Based on this result, Jeng and Wells (2000) recommend the consideration of the different financing stages to analyse VC activities, a method that has been mostly applied in later research (e.g. Schertler 2003; Romain & La Potterie 2003).

Besides the liquidity of the stock market, Félix, Pires, and Gulamhussen (2012) found evidence for a positive correlation between stock market growth and VC activity. The result is only statistically significant for later stage investments. This is consistent with Jeng and Wells (2000) and Schertler (2003), who did not find a significant impact on early stage investments.

Another variable, that was widely analysed, is GDP growth. Gompers and Lerner (1999) found that GDP growth strongly impacts the demand of VC investments. It increases the opportunities for entrepreneurs and, thus, increases capital demand for them. Similar results are found by Félix, Pires, and Gulamhussen (2012) as well as Romain and La Potterie (2003), who identify VC activity and GDP growth rate as being pro-cyclically related. VC activity is accompanied by periods of high GDP growth and vice versa. However, against their expectations, Jeng and Wells (2000) did not find any significance in GDP growth in their cross-country analysis.

The positive impact of GDP growth on VC activity can be reduced by a high labour market rigidity (Romain & La Potterie 2003). The influence of labour market rigidity is significant and can negatively impact early stage financing; however, later stage investments are not affected (Jeng & Wells 2000; Félix, Pires, & Gulamhussen 2012). The same effect is measurable for unemployment rates, being only significant for early stage financing (Cherif & Gazdar 2011).

Besides the previously mentioned determinants, the levels of interest rates are expected to influence VC activities (Romain & La Potterie 2003; Félix, Pires, & Gulamhussen 2012). In general, reduced interest rates encourage investors to invest their money in alternative asset classes with higher return potential such as VC funding (Gompers & Lerner 1999).

### **2.3 The impact of earlier crises on the venture capital industry**

The International Monetary Fund regards the economic crisis, caused by the coronavirus, as the worst economic downturn since the Great Depression in 1930 (Gopinath 2020). The pandemic started in December 2019 and the end is still not visible (WHO 2020a). Therefore, the availability of literature about the impact of Covid-19 on the VC industry is limited. Nevertheless, there is a considerable amount of literature on the impact of previous economic crises on the VC industry available from which a lot can be learned.

The collapse of the technology bubble in 2000 can be considered as the first meaningful event. Previous research shows that the burst of the technology bubble and its impact was relatively restricted to particular industries (Townsend 2012), while for instance; the Covid-19 crisis is a global crisis with impact across all industries (Ludvigson, Ma, & Ng 2020; Hassan, Hollander, Lent, & Tahoun 2020). VCs that are more exposed to the information technology industry faced difficulties in raising capital from limited partners, and were, therefore, more likely to invest in non-information technology companies afterwards. The same shift was measurable for information technology related VCs with sufficient capital due to expected liquidity constraints in the future (Townsend 2012). Furthermore, start-ups that received funding during the crisis were in general more mature than before the bubble collapsed (Green 2004; De Vries & Block 2011). Against the general expectations, the average funding per round during the technology crisis increased compared to the funding amount before the dot-com bubble inflated (De Vries & Block 2011). This can be explained by the heated state of the VC market shortly before the collapse of the technology bubble (Green 2004), meaning, the decrease experienced after the collapse was not strong enough to offset the increase during the bubble inflated (De Vries & Block 2011). All samples were limited to United States based companies.

Previous studies have shown the impact of the global financial crisis in 2008 on the VC industry. Most early studies concluded with a negative impact, ending up in a decrease for both the number of funding rounds as well as the amount of capital raised per funding round (Block & Sandner 2009; Block, De Vries, & Sandner 2010; De Vries & Block 2011). This impact differs, depending on the stage of the investment. Across all industries, the number of financing rounds for early stage funding decreased, while later stage funding experienced a greater decrease in the amount of funds per round (Block, De Vries, & Sandner 2010). This can be explained by the fact that start-ups in earlier stages are able to wait for a better and more stable financing environment, whereas ventures in later stages are extremely dependent on cash

availability (Block & Sandner 2009). The measured slowdown of VC activity is more present in the United States than other countries. However, Conti et al. (2019) only measure a decrease in the number of financing rounds but offer no evidence for a decrease of funding amount per round during the global financial crisis, instead they see a shift towards the funding of start-ups within the core sector of VCs. Funds of core start-ups are approximately 9% higher in comparison to non-core start-ups. De Vries and Block (2011) likewise noticed a shift towards core projects for VC investments during the crisis, mostly explained by worsened exit and fundraising conditions. Especially later stage financing is strongly dependent on exit market conditions (Jeng & Wells 2000; Gompers & Lerner 2004). Additionally, a reduction of syndicates was measurable for later stage funding (De Vries & Block 2011), forcing VCs to avoid experimentation and focus on their core sectors (Conti et al. 2019), which is consistent with the previous results. The sample only included United States based companies.

However, earlier experiences must be carefully evaluated against the uniqueness of the current crisis. Covid-19 contemporaneously disrupts demand, supply and productivity across all countries with devastating economic, health and social consequences, likely to last for long term rather than only a few weeks (Ludvigson, Ma, & Ng 2020). While previous events are associated with immediate liquidity shocks, Hassan et al. (2020) concluded the main concerns of public companies within the first few months were the decrease in demand, increase in uncertainty, and closure of production facilities along with the disruption of the supply chain. Within the first quarter of the pandemic, financing concerns were relatively low but became more important in the second quarter, although still far below the previously mentioned aspects. Furthermore, shortly before the pandemic started, the VC market was healthy and had an all-time high of \$276 billions of dry powder (committed but not invested capital) available (Vartabedian 2020). Therefore, possible funding decisions should more likely be influenced by determinants rather than liquidity concerns (Howell et al. 2020). In their first empirical study, Marco Groth

Howell et al. (2020) saw a decrease in the number of funding rounds between March and April 2020 in the United States. Similar to previous economic crises, the measured downturn was concentrated in early stage financing. A serious limitation of these findings, however, is in the early stage of the crisis. On March 11<sup>th</sup>, 2020, the WHO declared the coronavirus outbreak as a pandemic (WHO 2020a).

### 3 Hypothesis

The previous chapter discussed empirical results of past crises and the general determinants that impact the VC activities, being the basis for the hypotheses of this research paper.

The Covid-19 crisis immediately affected most parts of the global economy. Resulting economic consequences are devastating not only for the short term, but potentially for the long term (Ludvigson, Ma, & Ng 2020). Therefore, a large amount of new uncertainty evolved that potentially affects VC investment activities. Even if VCs constantly develop new operating and contracting practices in order to handle high uncertainty, the nature of the current circumstances are significantly different from the type of uncertainty that VCs have been historically confronted with (Gompers et al. 2020). The previously discussed literature has examined VC investment activities during past crises, finding a decline in the number of investments. Howell et al. (2020) already measured a first decline between March and April 2020, the beginning of the crisis. This effect is expected to stay constant during the current crises, leading to the first hypothesis:

***H1:** The number of VC financing rounds is lower during the Covid-19 crisis.*

Overall, previous crises did not only harm the number of investments, but also had a strong impact on the amount of money that each company received. The majority of research papers measured a substantial decline for both, the aggregate deal volume and average deal size (Block

& Sandner 2009; Block, De Vries, & Sandner 2010; De Vries & Block 2011; Howell et al. 2020). So far, no research has been published measuring the early impact of the current pandemic to the deal amount. Nevertheless, it is expected to see similar behaviours to past crises, which leads to the second hypothesis:

***H2:** The average deal amount of VC financing is lower during the Covid-19 crisis.*

In addition, previous research distinguishes between first and later rounds. First rounds are defined as the round in which a company receives an investment from a VC for the very first time. Later rounds include all financing rounds after the first round. Block & Sandner (2009) justify their separation with the following reasoning. First rounds are used to provide start-ups with initial seed money, while later rounds are required to fund further development, internationalization efforts and marketing. To maintain consistency with previous literature, the same approach will be followed but justified with different reasoning. First rounds are not necessarily characterized as seed money since the company stage can already have been developed further (Gompers 1995). Nevertheless, first rounds indicate a higher uncertainty and information asymmetry compared to later rounds since the company gets intensively screened for the first time. In contrast, later rounds mostly appear as follow-on investments after the achievement of pre-designed milestones that are used to reduce uncertainty (Sahlman 1990; Cumming, Fleming & Schwienbacher 2005). It is important to point out that the simple differentiation between first and later rounds that are equated with early and later stage investments could lead to biased results. Therefore, this research paper follows the approach of Cumming, Fleming and Schwienbacher (2005) which extend the separation between first and later rounds by the different company stages, used as independent variables, within their multivariate regression analysis. This approach gets further substantiated by the previously discussed factors of general determinants that impact VC activities. Different financing stages

experience different effects, and thus, Jeng and Wells (2000) already recommended the consideration of the different financing stages while analysing VC activities. Thus, a third hypothesis can be formulated:

***H3:** Different financing stages are impacted differently by the Covid-19 crisis.*

In general, VCs focus on company stages or industries when allocating their funds to portfolio companies (Sahlman 1990). The importance of different stages is already highlighted with hypothesis 3, leading to a further analysis of different industry sectors. The uniqueness of the pandemic increases the expectation of the importance of sector specific investments. While searching for possible investments, VCs face the trade-off of either investing in sectors where they have already developed a deeper knowledge or taking opportunities that may arise in a different industry (Conti et al. 2019). Outside their core sector, VCs have limited monitoring and screening skills (Gompers, Kovner, & Lerner 2009), leading to a higher amount of uncertainty (Conti et al. 2019). In general, uncertainty is higher for younger companies, making investments into further developed companies less risky (Sapienza & Gupta 1994). Conti et al. (2019) suggest that information problems are high for young companies, defined as seed and early stage, while they are less severe for older companies. In order to overcome the missing expertise, VCs tend to syndicate with other investors, giving them the possibility to validate their own rational against other more knowledgeable sources (Lerner 1994; Brander, Amit, & Antweiler 2002). During previous crises, mainly the dot-com bubble and the global financial crisis, VC syndication decreased in overall tendency and size (De Vries & Block 2011). A similar behaviour during the current crisis is expected. Therefore, with less syndicate partners available and an increased uncertainty a fourth hypothesis can be formulated:

***H4:** For seed and early stage investments, lead VCs tend to invest more in companies that operate within their core sector during the Covid-19 crisis.*

## 4 Data and Methodology

### 4.1 Data collection

The data is collected from Thomson Reuters Eikon (henceforth TRE) that has a history of data collection that goes back to 1961.<sup>1</sup> TRE mainly uses public sources for its data collection, which gets updated on a daily basis (Gompers & Lerner 2004). This database has been used in various studies related to the VC industry (e.g. Bygrave 1987; Sorenson & Stuart 2001; Gompers & Lerner 2004; Block, De Vries, & Sandner 2010; Townsend 2012; Conti et al. 2019). Röhm, Merz, & Kuckertz (2019) show the dominance of TRE as the most extensively used database with the highest number of appearances in academic papers. It has been validated against real contracts by previous researchers with the result of it being utilised as an unbiased database related to the financing of VC investments (Kaplan, Strömberg, & Sensoy 2002).<sup>2</sup> Considering the timeliness of the topic, a snapshot of the database was collected on the 10<sup>th</sup> November 2020.

### 4.2 Sample construction

The whole population of TRE includes a dataset of 264,480 funding rounds that occurred until the end of September 2020. Out of this population, the sample was constructed. The pre-crisis period is almost six quarters long, starting in October 2018 and ending on March 11<sup>th</sup>, 2020, the day that the coronavirus outbreak was officially declared as a pandemic by the WHO (WHO 2020a).<sup>3</sup> The crisis period begins from March 12<sup>th</sup>, 2020 and ends on September 30<sup>th</sup>, 2020.

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<sup>1</sup> Previous versions are *Thomson One*, *VentureXpert*, and *Venture Economics*.

<sup>2</sup> Overall, TRE provides unbiased data for financing rounds. Nevertheless, noisy measures exist and about 15% of the financing rounds are excluded. This leads to an overall average understatement of about 20% of financing commitments. Furthermore, the database oversamples Californian companies and larger rounds (Kaplan, Strömberg, & Sensoy 2002).

<sup>3</sup> Similarly, on March 13<sup>th</sup>, 2020, the President of the United States officially announced a national emergency declaration for all states, tribes, territories and the District of Columbia due to the Covid-19 pandemic (FEMA 2020). The short time difference and the inclusion of non-US VCs within the analysis gives the earlier announcement of the WHO more importance, stating March 12<sup>th</sup>, 2020 as the first day of the crisis period.

The end date was chosen due to the on-going situation of the pandemic and to ensure the highest available data quality. Several variables that are used within the regression analysis are made available after the investment date within the TRE database.

In total, 23,179 investments fall into the defined sample period. Only investments in companies where the headquarter is located within the United States and the funding round is disclosed with an equity amount greater than or equal to one are included. The sample excludes corporate VC investments in order to focus exclusively on independent VCs. Corporate VCs differ considerably in their source of capital and motivation regarding the target of strategic goals (Gompers & Lerner 2000). To maintain consistency with previous literature, the remaining data is limited to seed, early stage, expansion, and later stage investments, ending up with a final sample of 8,802 funding rounds. Out of this sample, 2,434 funding rounds occurred during the crisis period and 6,368 investments within the pre-crisis period. Table 2 shows the steps of the sample construction.

### **4.3 Empirical strategy**

The empirical analysis is used to examine the validity of the hypotheses that were constructed related to the impact of Covid-19 on the VC industry. Different statistical models were created, which account for characteristics of the investigated VCs and companies. Definitions of all variables are stated in Table 3. Pearson's correlation was used to measure the strength of the association between all studied variables. As discussed in section 3, first and later rounds are evaluated separately throughout the whole empirical analysis. Statistical analysis was done using SPSS Version 26.0 statistic software package (IBM Corp. 2019).

Firstly, a univariate analysis of the mean and median was conducted to test hypothesis 1 and source any general patterns within the data. Differences between pre-crisis and crisis period were tested by a two-sample t-test. In a second step, different semi-logarithmic regression

models were created. Correlation values and variance inflation factors were calculated to ensure that multicollinearity is not an issue for the regression results. In order to account for possible heteroskedasticity robust standard errors were applied (Petersen 2008) and follow the general approach of Hayes and Cai (2007) to use HC3 or HC4 in OLS regressions. To ensure that outliers do not influence results, the same regressions were repeated after winsorizing the round amount (Dixon 1980; Ghosh & Vogt 2012) and outcomes compared. In order to set the percentile locations to winsorize, the absolute deviation around the median was applied to analyse the dataset for possible outliers (Leys et al. 2013).

The following regression model is used to examine the baseline effects of Covid-19 to the United States VC industry and test for hypothesis 2:

$$\ln(\text{Round amount}_{j,r}) = \alpha + \beta_1 \text{Covid}_{19,r} + \beta_2 \text{Core}_{j,r} + \beta_3 \text{Investment Stage}_{j,r} + \beta_4 \text{Location}_j + \beta_n X'_r + \gamma_k + \delta_t + \varepsilon_{j,r}$$

Equation (1)

The dependent variable is the natural logarithm of the financing amount that company  $j$  receives in round  $r$ . Only equity financing is included. The natural logarithm is used to normalize the distribution of the explained variable and eases the interpretation of the results (Benoit 2011).  $\text{Covid}_{19,r}$  is the main regressor of interest, which equals to one for VC investments that were made during the crisis period, and zero otherwise. Besides the pandemic impact, round amount gets influenced by several factors, such as financing stage. Failing to control for these factors could bias the main estimator  $\beta_1$ . For that reason, a large range of control variables was added.  $\text{Core}_{j,r}$  is a dummy variable that equals to one if a company  $j$  operates in the core sector of the lead VC in round  $r$ .<sup>4</sup> Following the approach of Conti et al. (2019), lead VCs are those that participated in the largest number of financing rounds prior the

<sup>4</sup> This study uses Thomson Reuters Business Classification (henceforth TRBC) to define core sectors. TRBC is a market-based classification system which separates between Economic Sectors (2-digit), Business Sectors (4-digit), Industry Groups (6-digit), Industries (8-digit) and Activities (10-digit) (Reuters 2020). Unless stated differently this research paper uses the Economic Sectors for the  $\text{Core}_{j,r}$  variable.

investment date. Core sectors are defined as the sector in which a VC made more than 50% of all its investments over time.  $Investment\ Stage_{j,r}$  defines the stage of company  $j$  in round  $r$ . Stages are separated between seed, early stage, expansion and later stage.  $Location_j$  is related to the headquarter of company  $j$  and distinguishes between California, New York, Massachusetts and all other states. The highest total volume of investments in 2019 appeared in California, followed by New York and Massachusetts (NVCA 2020). Therefore, it is expected that companies located in these areas receive a greater amount of funding compared to elsewhere. Additional round specific control variables in the vector  $X'_r$  include syndicate, business angel, government program, university program and non-US VC. The variables equal to one if at least two investors, one business angel, one governmental sponsored program, one university sponsored program or one foreign VC participated in a given round  $r$ , respectively, and zero otherwise. Furthermore, if the sample is not separated between first and later rounds the vector  $X'_r$  includes round status, being one for first rounds, and zero for later rounds. Fixed industry effects are included through  $\gamma_k$ , corresponding to the industries based on the 2-digit TRBC industry classification. Finally, to absorb inter-temporal variation within the data, monthly fixed effects for the period in which an investment was made are included by variable  $\delta_t$ . Compared to previous research the control variable company age was excluded from the regression model due to a large number of missing values within the dataset. In total 2,059 datapoints (~25%) reported no founding date or one that follows the date of their first received investment. The replacement by median values, as it was done in previous research (e.g. Block & Sandner 2009) was avoided as it may lead to inconsistent bias (Graham 2009; Kang 2013). After analysing the baseline effect of the Covid-19 crisis on the round amount, equation (1) was modified by introducing an interaction between  $Covid\_19_r$  and  $Investment\ Stage_{j,r}$  in

order to test hypothesis 3. Except for the interaction term, no other changes are done. The new equation is:

$$\begin{aligned} \ln(\text{Round amount}_{j,r}) = & \alpha + \beta_1 \text{Covid}_{19_r} + \beta_2 \text{Core}_{j,r} + \beta_3 \text{Investment Stage}_{j,r} \\ & + \beta_4 \text{Covid}_{19_r} \times \text{Investment Stage}_{j,r} + \beta_5 \text{Location}_j + \beta_n X'_r + \gamma_k + \delta_t + \varepsilon_{j,r} \end{aligned}$$

*Equation (2)*

To test Hypothesis 4, equation (2) was modified by introducing an additional interaction between  $\text{Covid}_{19_r}$  and  $\text{Core}_{j,r}$ . By default, the variable  $\text{Core}_{j,r}$  is based on the 2-digit TRBC sector. The regression was repeated, using the 4-digit TRBC sector for the  $\text{Core}_{j,r}$  variable. As previously discussed in chapter 3, this research paper follows the approach of Conti et al. (2019) which found that information problems are most severe for younger companies. Therefore, expansion and later stage investments are excluded. The new equation is:

$$\begin{aligned} \ln(\text{Round amount}_{j,r}) = & \alpha + \beta_1 \text{Covid}_{19_r} + \beta_2 \text{Core}_{j,r} + \beta_3 \text{Covid}_{19_r} \times \text{Core}_{j,r} + \beta_4 \text{Investment Stage}_{j,r} \\ & + \beta_5 \text{Covid}_{19_r} \times \text{Investment Stage}_{j,r} + \beta_6 \text{Location}_j + \beta_n X'_r + \gamma_k + \delta_t + \varepsilon_{j,r} \end{aligned}$$

*Equation (3)*

The special circumstances of the crisis create the concern that the overall impact is biased by large investments within the healthcare sector that were mainly driven by the pandemic.<sup>5</sup> Particularly the rush to develop a vaccine and companies producing innovative products that could become acquisition targets for big pharmaceutical groups are more likely to lead to extraordinary investments (Kruppa 2020). To circumvent this issue a new sample was created that is restricted to investments outside the healthcare sector. This limitation eliminates the possibility that the coefficients of the regression are biased by a small sub-sample of healthcare

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<sup>5</sup> First reports stated that for the healthcare sector “compared to the same quarter in FY’19, dollars invested increased 50%, and the number of deals also increased by 25% in Q3’20”, which includes “a total of \$3.2B” that “was raised this quarter through 17 mega-rounds” (deal volume > \$100M), “making up 40% of total” healthcare “deal dollars raised in Q3’2020” (PWC & CB Insights 2020). “Given the widespread impact of the pandemic, it’s no surprise that companies developing potential vaccines or therapeutics focused on COVID-19 continue to be a key target for VC investors” (KPMG 2020).

related investments, leading to a wrong result for the whole VC industry. All regressions were repeated with the new sub-sample to review if previous findings hold. Finally, to conduct robustness checks, two other pre-crisis periods, six months and twelve months, were used.

#### **4.4 Data description**

The number of funding rounds and the total funding amount in the United States between 2010 and September 2020 are displayed in Figure 1. While analysing the Covid-19 quarters, two particular trends stand out. First, quarter two of 2020 shows a slight decrease for number of rounds and funding amount compared to the previous quarter. Nevertheless, the reduction is not high enough to indicate a negative impact of the pandemic on the VC industry since quarter two seems to be on an equal level compared to the quarters prior to 2020. Second, the aggregate VC investments reach their peak in quarter three of 2020, suggesting that there is no negative impact of the Covid-19 crisis on the VC industry at large.

Table 4 provides a general overview about the characteristics of the funding rounds on a year-over-year basis. Overall, it seems that the general characteristics are not significantly affected by the pandemic. Only the average company age within first rounds shows a significant increase. This is consistent with the findings of past crises that VCs tend to invest in relatively mature start-ups during periods of crises (Green 2004; De Vries & Block 2011). The proportion of different industry sectors changes only slightly based on the number of deals. Interestingly, using the round amount to calculate the industry shares, a clear tendency towards a greater proportion of healthcare investments during the Covid-19 crisis stands out. Especially for later rounds, the proportion of healthcare increased by approximately 49%. This finding supports the previously mentioned concerns that overall industry results may be skewed by a small proportion of large investments that are driven by the special circumstances of the pandemic.

## 5 Results

### 5.1 Univariate analysis

Table 5 and Table 6 show the results of the univariate analysis for number of rounds and round amount, respectively, based on a year-over-year comparison. The left side of Table 5 and Table 6 show the results for the whole sample, i.e. including healthcare, while the right side shows results for the dataset excluding the healthcare sector. Overall, the number of rounds per week show a tendency to decrease except for seed stage investments. Nevertheless, the results lack statistical power. Only later stage investments of later rounds decrease at 10% significance. Once the healthcare sector is excluded, later rounds show an overall decrease in the number of financing rounds per week of 9%, being statistically significant at the 5% level. The individual investment stages show the same patterns, but without statistical significance.

Hypothesis 1 assumes that the number of financing rounds is lower during the Covid-19 crisis. As previously shown, the overall tendency clearly states a reduction but lacks statistical power. Thus, hypothesis 1 needs to be rejected.

The situation is fairly different for the round amount. Surprisingly, only positive impacts are statistically significant. Especially for later rounds, the average round amount increased by 27% at the 1% significance level. The separation between the different financing stages gives further insight, showing that only investments into later stage companies are significantly affected. Excluding the healthcare sector leads to a similar result for later rounds. The overall impact is lower and shows a reduced statistical significance. However, later stage investments increase even more, being significant at usual conventional levels. First rounds show an increase for investments in companies being at the seed or expansion stage. Nevertheless, both results are only statistically significant at the 10% level. The dataset without healthcare investments shows a similar pattern for the expansion stage. Interestingly, any negative impact

lacks statistical power. The results give a first indicator for hypothesis 2, which will be further analysed in the following chapter.

## 5.2 Regression analysis

Table 7 to Table 11 present the semi-logarithmic regression results of the different samples. Each funding round between October 2018 and September 2020 represents one observation unit. In order to test for hypotheses 2 to 4, the different equation results are stated separately. Within Table 7 to Table 9, Column (1) presents the result of equation 1, column (2) of equation 2. The results of equation 3 are stated in Table 10 and Table 11. All results are distinguished between all, first and later rounds. The dependent variable is the natural logarithm of round amount and therefore, the interpretation of the coefficients is the standard semi-elasticity. In case of dummy variables, the results must be interpreted as follows. One unit increase in X yields a  $100 * [e^{\beta} - 1]$  percentage change in Y (Van Garderen & Shah 2002). Equation 2 and 3 include the interaction terms and therefore, the Covid-19 coefficient states the impact on later stage investments during the pandemic, being the base category. For the interpretation of each variable within the models, the assumption of ceteris paribus terms holds.

Starting with equation 1 the coefficient of Covid-19 is significant at the 1% level for all investment rounds. Surprisingly, the effect seems to be positive for investments that occurred during the crisis period. The coefficient of .144 indicates that the investment amount increases on average by 15% for all rounds. First rounds show a stronger effect with 19% while later rounds increase by 14%. As expected, first rounds receive on average a lower amount compared with later rounds. In general, companies operating in the core sector of the lead VC receive a higher investment amount at 1% significance. This finding holds for later rounds, while the negative coefficient of first rounds lacks statistical power. Companies that are further developed in terms of company stages, usually raise a higher amount of funding per round. The

estimated coefficients of the investment stages are all statistically significant at the 1% or 5% level, even within first and later rounds, supporting the reasoning to further differentiate between the financing stages. Failing to control for financing stages, may lead to the inflation of the Covid-19 crisis coefficient. In general, companies headquartered in California receive a greater investment amount, followed by Massachusetts and New York, respectively. The ranking differs for first and later rounds. First round investments are usually higher in Massachusetts, while later rounds dominate in California. Moreover, equation 1 estimates highly statistically significant effects for the remaining independent variables, except the attendance of university sponsored programs within first round investments.

In order to exclude the previously mentioned concerns regarding possible outliers and exceptional investments within the healthcare sector, the same model has been applied to the restricted samples. Table 8 shows the results without healthcare investment rounds, while Table 9 displays the values for the winsorized dataset. Overall, basic patterns hold for significance and sign. The magnitude of the coefficients changes slightly. The only considerable difference occurs for the financing stages, where the gaps rise if healthcare investments get excluded. The coefficient of Covid-19 for later rounds has less statistical power. Winsorized data are still within the conventional level, while the exclusion of healthcare leads to a p-value below 10%.

Hypothesis 2 assumes a lower round amount for investments that occur during the Covid-19 crisis. As previously shown, the opposite effect was measured. Thus, hypothesis 2 is rejected.

Equation 2 is used to test hypothesis 3 and therefore, the model was extended by interaction terms between  $Covid_{19,r}$  and  $Investment\ Stage_{j,r}$ . Significant coefficients of the interaction terms would indicate that Covid-19 influences the relationship between round amount and the different investment stages. Seed stage investments seem to decrease by 25% during the crisis period. Nevertheless, with a p-value below 10% the coefficient shows a lower

significance than usual conventional levels, being only a weak argument to prove the underlying hypothesis. However, early stage and expansion stage investments are negatively affected, being statistically significant at 1% and 5% level, respectively. Later stage investments show a highly significant relation with Covid-19. The round amount increases by 44% during the pandemic compared to the pre-crisis period.

Once the sample is separated into first and later rounds, the impact of the pandemic on the different financing stages becomes clearer. First round investments do not differ during the pandemic compared to pre-crisis times as all interaction terms are not statistically significant. Later round investments in later stage companies increase significantly at the 1% level, while early stage and expansion stage investments decrease with the same significance. The relation between Covid-19 and seed stage seems to be not given once the sample gets separated. There is, not surprisingly, no change in the pattern in the other coefficients. Compared to the previous model sign, significance, and magnitude of the effects are similar.

The results of Table 8 and Table 9 are used again in order to exclude possible bias of the previously described findings. Overall, the basic patterns hold for sign, while significance and magnitude change. The sample without the healthcare sector, shows a higher decrease for seed investments during the pandemic, which is now statistically significant at the 1% level. The coefficient of expansion stage investments during Covid-19 is still negative, but the p-value is only below the 10% level. Nevertheless, the differentiation between first and later rounds leads to the same result for all samples. First round investments do not differ compared to normal times at conventional levels, while for later rounds early stage, expansion stage and later stage investments are statistically significant affected.

Hypothesis 3 assumes that the impact of the Covid-19 crisis differs depending on the financing stage. Similar to past crises, the described regression results of the current pandemic show

divergent significance and magnitude of effects on financing stages by the crisis. Even if the exclusion of the healthcare sector inflates the coefficients and changes significance levels, the impact on financing stages is still diverse. Hence, hypothesis 3 is confirmed.

Finally, equation 3 is used to test hypothesis 4 and therefore, a second interaction term between  $Covid_{19,r}$  and  $Core_{j,r}$  was included. The dataset only includes investments in seed and early stage companies. Table 10 uses the 2-digit TRBC economic sector to define the core business of a lead VC; Table 11 uses the 4-digit TRBC business sector. The first column includes all seed and early stage investments, the second column only seed investments and finally the third column only investments into early stage companies. Overall, the regression shows that lead VCs tend to invest more within their core sectors during the Covid-19 crisis compared to pre-pandemic times. Deciphering between seed and early stage investments leads to the conclusion that the findings are explained by early stage investments. Nevertheless, both results are only significant at the 10% level. Distinguishing between first and later rounds gives more clarity regarding the main driver of this effect. The regression shows that for seed investments, lead VCs do not tend to invest more within their core sector during the Covid-19 crisis, either within first or later rounds. However, during the pandemic, early stage companies operating in the core sector of the lead VC tend to receive higher funding within their first financing round in comparison to pre-crisis times. The investment amount increases by approximately 35%. For later rounds, no significant difference between pre-crisis and crisis period was measured. The same patterns hold while using the 4-digit TRBC business sector to define the core business of the lead VC. Table 11 shows a significant increase in financing rounds of early stage companies within the core sector of the lead VC, explained by first rounds, compared to pre-crisis times.

Hypothesis 4 assumes that lead VCs tend to invest more into companies operating in their core sector during the Covid-19 crisis. While only looking for the overall sample (first column of

All Rounds), it could be concluded that this hypothesis is true. Nevertheless, as previously shown, this effect is exclusively explained by investments into early stage companies, but not through seed investments. Thus, hypothesis 2 needs to be rejected for the overall industry; however, it would be confirmed if only investments into early stage companies are looked at.

In order to test if the results obtained by the previous models hold, a different time-window was used, where the pre-crisis period is reduced to six respectively twelve months. Overall, patterns hold in sign, significance and magnitude of the effects. When reducing the sample size to a lower time span, results slightly decrease by decimals. If the different quarters of Figure 1 are compared, this finding seems to be logical. The average value of Q2 2019 and Q3 2019 seems to be equal to the average value of Q4 2019 and Q1 2020. The baseline model includes Q4 2018 and Q1 2019 where the average amount seems to be slightly lower.

### **5.3 Discussion of the results**

Reviewing the year 2020, so far, it might be reasonably expected that the United States VC industry is negatively affected by the global pandemic. Surprisingly, the results show that, unlike earlier crises, this crisis during 2020 has impacted the VC sector differently. Compared to previous crises, where the measured impact was predominantly negative, the number of investments did not decline significantly.

The overall robustness of the VC industry could be explained by more general environmental factors. One reason could be the high adaptability of VCs to governmental restrictions, such as lockdowns, by being more able to pivot to remote working and an increased acceptance of virtual meetings as viable alternatives to the standard face to face meetings (Gompers et al. 2020). Furthermore, VC portfolios may benefit from operating in such a volatile and disruptive environment. An increase in volatility may raise the portfolio companies' value, given that we think of that company as a real option (Trigeorgis 1993; Li 2008; Gompers et al. 2020).

Another surprising fact that was measurable is that companies received a higher funding per round compared to normal times, which was mainly driven by later stage investments. While trying to explain the positive impact on later stage investments, three main factors stand out.

Firstly, IPOs are considered as the strongest driver of later stage investments (Jeng & Wells 2000). This can be explained by the potential return IPOs offer to the VC funds. Figure 2 shows that 2020 has seen an outstanding performance of the United States IPO market. Since April, shortly after the declaration of the global pandemic, the market constantly increased and finally reached its peak in September, being the highest month in more than a decade. Furthermore, at the end of August, the U.S. Securities and Exchange Commission approved a new rule for primary direct listings at the NYSE, which highly appeals to VCs (Osipovich 2020).<sup>6</sup>

Secondly, the stock market growth positively correlates with later stage investments (Félix, Pires, & Gulamhussen 2012). On February 19<sup>th</sup>, 2020, the S&P 500 index closed at its new all-time high. On March 23<sup>rd</sup>, 2020, just 35 trading days later, the three major indices NASDAQ, Dow Jones, and S&P 500 closed in the red and reached their lowest level year-to-date after the senate failed to vote through the coronavirus economic relief package for a second time (Banerji, Isaac, & Chiu 2020). Since then, all three indices are on an impressive recovery.<sup>7</sup>

Lastly, the large amount of dry powder available shortly before the crisis indicates that the market was in a healthy state, making it more resistant to economic downturns. The dry powder is probably used to bring existing portfolio companies through the crisis by providing follow-on funding, i.e. through later rounds, if a company had to delay their exit plans.

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<sup>6</sup> The new rule allows companies going public to raise capital on the NYSE without going through an underwritten public offering. Previously, it was not allowed for companies to raise new funds through direct listing (Osipovich 2020). This approval has been under discussion since end of 2019. After a first approval by the U.S. Securities and Exchange Commission on August 26<sup>th</sup>, 2020 it has been on stay since August 31<sup>st</sup>, 2020 due to a petition of the Council of Institutional Investors. This petition has been rejected on October 16<sup>th</sup>, 2020 and since then the rule changes take effect (Smith 2020; New York Stock Exchange LLC 2020).

<sup>7</sup> Annualized growth rate between March 23<sup>rd</sup>, 2020 and September 30<sup>th</sup>, 2020: Dow Jones +63.04%, NASDAQ +121.05%, S&P 500 +73.37%. (Williamson 2020)

The decline of seed stage, early stage and expansion stage investments can be best explained through the findings of previous research. In general, the IPO market and stock market growth only influence later stage investments, while investments into younger companies are not affected. Recently, Howell et al. (2020) found systematic evidence that early stage investors react significantly more sensitive to business cycles compared to later stage investors. The pandemic caused a decline of GDP growth, which is expected to be -4.3% for the United States by the end of 2020 (IMF 2020b).<sup>8</sup> Furthermore, the unemployment rate negatively affects early stage investments (Cherif & Gazdar 2011). Starting at 3.5% in February 2020, the pandemic caused millions of job losses, resulting in a 14.7% unemployment rate in April 2020. After a recovery, the September 2020 unemployment rate was at 7.9%, still far above the pre-pandemic level (U.S. Bureau of Labor Statistics 2020).

Excluding the healthcare sector, the overall negative impact of Covid-19 on seed investments doubled. This can be explained by extremely high investments within the healthcare sector that are stated in the note of Table 6. In general, the highest stake of seed investments come from business angels with lower cash availability compared to VCs and thus, a more cautious behaviour about investment decisions during the pandemic is expected (Wiltbank 2005).

Finally, evidence for the allocation of relatively more funding into companies operating in the core sector of a lead VC during the pandemic was found. This effect is strongest and solely significant for first round early stage investments. Outside their core sector, VCs have limited monitoring and screening skills (Gompers, Kovner, & Lerner 2009), leading to a greater amount of uncertainty (Conti et al. 2019). It can be expected that VCs step away from experimentation outside their core sector to lower risk and rely on own knowledge. It is also expected that later rounds are not affected since they most likely occur as follow on investments

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<sup>8</sup> Status as of October 2020. In April the projection was even worse with -5.9% for 2020 (IMF 2020a).

in existing portfolio companies (Sahlman 1990; Cumming, Fleming & Schwienbacher 2005) and therefore, a reduction of risk and uncertainty compared to first rounds is already given. The missing impact on seed investments could be explained through the highly diversified company portfolio of seed investors (Wiltbank 2005).

## 6 Conclusion

In this paper, the impact of the Covid-19 crisis on the United States VC industry within the first six and a half months of the pandemic is analysed. Although the overall expectation assumes a drop in VC investment activity, an effect that would be equivalent to the experiences of previous economic crises, there is no evidence for the decrease of funding rounds. Furthermore, companies received in general a higher round amount during the crisis period compared to pre-pandemic times. This effect is mainly driven by later stage investments, which increased by 44%. In conclusion, individual financing stages were impacted differently. The possible explanations most likely correlate with general determinants that affect VC activities and have been identified in a large number of previous studies. The current downturn of the business cycle negatively impacts investments into younger companies, while later stage investments are positively influenced by the strong IPO market and stock market growth.

For many years, VCs learned to deal with large amounts of uncertainty. As previously observed during the global financial crisis, lead VCs tend to invest more in early stage companies operating in their core sector within first rounds in comparison to pre-pandemic periods in order to utilize and leverage their own expertise and knowledge.

Although the first vaccines have been rolled out, the pandemic is still ongoing with an end not currently visible. Nevertheless, this paper only gives insights to the short term impact of the pandemic, which could differ to the results in the long term. The long term impact of the pandemic will need to be considered and investigated during the aftermath of the pandemic.

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## Appendices

Table 1: Overview determinants of past research

Determinants + positive impact - negative impact 0 no statistically significant impact	Black & Gilson (1998)	Gompers & Lerner (1999)	Jeng & Wells (2000)	Scherter (2003)	Romain & La Poterie (2003)	Cherif & Gazdar (2011)	Felix, Pires, & Gulamhussein (2012)
Focus Region	Globally	United States	Globally	Europe	OECD	Europe	Europe
Capital Gain Tax Rates		-	0		0		
GDP Growth Rate		+	0		+	+	+
Initial Public Offering	+	0 (aggregate level)	+			0 early stage	+
Interest Rate (short-term)		+			+	0	
Interest Rate (long-term)		- (states level)			+	0	+
Labour Market Rigidity			- (early stage) 0 (later stage)	+	-		- (early stage) 0 (later stage)
Market Capitalization Growth			0 (early stage)	0 (early stage)		+	+
Private Pension Funds		+	+				
R&D Expenditure		+	+	+	+	+	0
Total Entrepreneurial Activity (TEA)					+		0
Unemployment Rate						- (early stage)	-

Table 2: Sample construction (Status 10<sup>th</sup> November 2020)

Total number of funding rounds between October 1 <sup>st</sup> , 2018 and September 30 <sup>th</sup> , 2020	23,179 obs.
- Investments outside the United States	11,903 obs.
- Funding round is not disclosed or shows an equity amount of zero	2,008 obs.
- Corporate Venture Capital investments	155 obs.
- Only seed/early/expansion/later stage as investment stage	301 obs.
- Exclude wrongly allocated Corporate Venture Capital and debt investments <sup>1</sup>	10 obs.
= Final sample	8,802 obs.
= Pre-Crisis Period	6,368 obs.
= Crisis Period	2,434 obs.

(1) Date	Company	Investment Type	Date	Company	Investment Type
31/05/2018	Cruise Automation Inc	CVC investment	23/12/2019	Rivian Automotive LLC	CVC investment
03/10/2018	Cruise Automation Inc	Debt financing	07/02/2020	JUUL Labs Inc	CVC investment
20/12/2018	JUUL Labs Inc	CVC investment	01/07/2020	Palantir Technologies Inc	CVC investment
07/05/2019	Cruise Automation Inc	Debt financing	10/07/2020	Rivian Automotive LLC	CVC investment
30/08/2019	JUUL Labs Inc	CVC investment	22/07/2020	Villagemd Chicago LLC	CVC investment

Table 3: Definition of variables

Variable name	Description
<i>Business Angel</i>	Binary variable that is equal to one if a minimum of one business angel participated in a given funding round, and zero otherwise. Both categories of Thomson Reuters Eikon, individuals and angel groups, are considered.
<i>Core</i>	Binary variable that is equal to one if the funded company $j$ operates in the 2-digit TRBC core sector of the lead VC, and zero otherwise. Core sectors are defined as the sector in which a VC made more than 50% of all its investments.
<i>Covid-19</i>	Binary variable that is equal to one if the funding took place during 11/03/2020 and 30/09/2020, and zero otherwise.
<i>Government Program</i>	Binary variable that is equal to one if at least one program that is financed by the government participated in a given funding round, and zero otherwise.
<i>Industry Effects</i>	Dummy variables that classify the economic TRBC sectors. Equals to one if a company operates in “Basic Materials”, “Consumer Cyclical”, “Consumer Non-Cyclical”, “Energy”, “Financials”, “Healthcare”, “Industrials”, “Technology”, “Telecommunications Services”, “Utilities”. Excluded dummy is “Technology”.
<i>Investment Stage</i>	Dummy variables based on Thomson Reuters Eikon investment stages “Seed”, “Early Stage”, “Expansion”, “Later Stage”. Equals the company stage at investment date. “Later Stage” is the excluded variable.
<i>Location</i>	Dummy variables that state the Headquarter of the company that received the investment. Equals to one if a company is located in California, Massachusetts, New York, Others and zero otherwise. Excluded dummy is “Others”.
<i>Non-US VC</i>	Binary variable that is equal to one if at least one VC investor outside of the US participated in a given funding round, and zero otherwise.
<i>Round amount (ln)</i>	Natural logarithm of the raised funding amount (\$m) that company $j$ receives in round $r$ . Only includes equity financing.
<i>Round Status</i>	Binary variable that is equal to one if the investment round was the first investment round of the company, and zero if it was a later round.
<i>Syndication</i>	Binary variable that is equal to one if the number of investors that participated in a given funding round is greater than one, and zero otherwise.

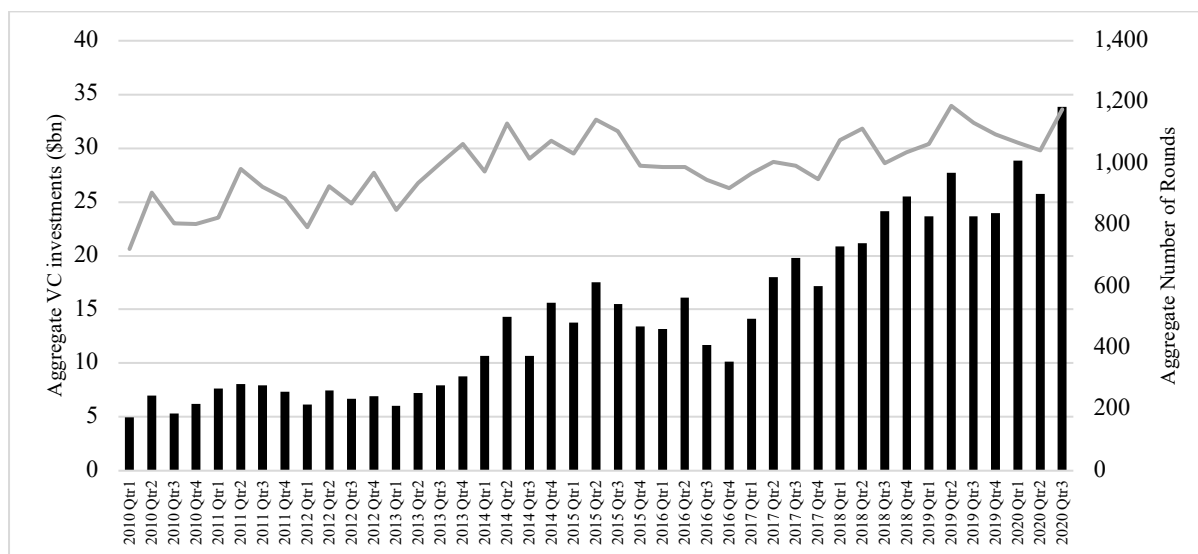


Figure 1: Aggregate VC investments and Number of Rounds, 2010 - 2020

Table 4: Characteristics of sample funding rounds

	First Rounds				Later Rounds			
	Pre-Crisis (12. Mar. 2019 – Sep. 2019)		Covid-19 (12. Mar. 2020 – Sep. 2020)		Pre-Crisis (12. Mar. 2019 – Sep. 2019)		Covid-19 (12. Mar. 2020 – Sep. 2020)	
Business Angel (%)	21.74	-	22.04	-	9.79	-	10.97	-
Government program (%)	4.23	-	3.69	-	4.09	-	4.56	-
Non-US VC (%)	20.68	-	23.65	-	21.76	-	24.72	-
Syndication (%)	72.62	-	76.11	-	61.20	-	62.39	-
University program (%)	2.00	-	1.23	-	0.52	-	0.80	-
Company age (in years): <sup>1</sup>								
Mean	3.62	**	4.16	**	6.75	-	6.71	-
Median	3.00	-	3.00	-	5.00	-	6.00	-
Industry (%):	Deal Number	Round Amount	Deal Number	Round Amount	Deal Number	Round Amount	Deal Number	Round Amount
Basic Materials	0.82	0.32	1.35	0.48	1.50	0.61	1.73	2.49
Consumer Cyclicals	6.70	5.97	4.56	3.06	5.53	6.36	2.96	3.84
Consumer Non-Cyclicals	8.93	3.94	9.98	7.73	4.43	4.45	5.18	3.33
Energy	0.24	0.05	0.12	0.06	0.23	0.09	0.37	0.10
Financials	2.94	6.41	4.56	6.50	3.28	6.61	2.90	7.34
Healthcare	16.45	31.81	17.61	38.99	19.57	15.42	22.63	23.01
Industrials	8.46	9.04	6.65	4.46	8.18	10.69	6.97	11.33
Technology	54.52	41.98	54.19	37.70	56.65	55.48	57.09	48.46
Telecommunications Services	0.59	0.42	0.62	0.82	0.46	0.20	0.06	0.00
Utilities	0.35	0.06	0.37	0.19	0.17	0.08	0.12	0.09
N funding rounds	851	851	812	812	1,737	1,737	1,622	1,622

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Chi-square test is used to analyse difference of frequency distributions. Two-samples t-test is used to analyse difference of means. Mann-Whitney U test is used to analyse difference of medians.

<sup>1</sup>Only non-missing observations are considered (N=3,758)

Table 5: Number of rounds

	Incl. Healthcare					Excl. Healthcare				
	Pre-Crisis (12. Mar. 2019 – Sep. 2019)		Covid-19 (12. Mar. 2020 – Sep. 2020)		Change (%)	Pre-Crisis (12. Mar. 2019 – Sep. 2019)		Covid-19 (12. Mar. 2020 – Sep. 2020)		Change (%)
	Mean	SD	Mean	SD	Mean	Mean	SD	Mean	SD	Mean
<b>First Rounds:</b>										
Number of rounds per week: <sup>9</sup>	29.14	6.65	27.07	5.60	-7 -	24.28	6.24	22.90	5.41	-6 -
by stage at financing:										
Seed	3.69	2.14	4.00	1.95	+8 -	2.66	1.90	2.52	1.35	-5 -
Early Stage	19.97	6.04	18.47	4.26	-8 -	16.83	5.55	16.00	4.42	-5 -
Expansion	4.00	2.22	3.43	2.10	-14 -	3.59	2.08	3.28	1.81	-9 -
Later Stage	1.52	1.09	1.17	1.02	-23 -	1.28	1.07	1.10	1.05	-14 -
<b>Later Rounds:</b>										
Number of rounds per week:	59.28	12.03	54.90	9.18	-7 -	47.31	7.59	43.00	8.58	-9 **
by stage at financing:										
Seed	1.28	1.07	1.45	1.09	+13 -	0.72	0.80	0.55	0.74	-24 -
Early Stage	21.83	6.49	21.00	4.59	-4 -	16.45	3.38	15.48	4.44	-6 -
Expansion	21.69	6.01	19.90	4.15	-8 -	19.34	5.34	17.34	4.00	-10 -
Later Stage	14.52	4.69	12.55	3.70	-14 *	10.79	3.97	9.62	2.90	-11 -
<b>N funding rounds</b>	2,588		2,434			2,108		1,924		

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Two-samples t-test is used to analyse difference of means.

Table 6: Round amount

	Incl. Healthcare					Excl. Healthcare				
	Pre-Crisis (12. Mar. 2019 – Sep. 2019)		Covid-19 (12. Mar. 2020 – Sep. 2020)		Change (%)	Pre-Crisis (12. Mar. 2019 – Sep. 2019)		Covid-19 (12. Mar. 2020 – Sep. 2020)		Change (%)
	Mean	SD	Mean	SD	Mean	Mean	SD	Mean	SD	Mean
<b>First Rounds:</b>										
Round amount (\$m):	11.00	28.34	12.17	26.42	+11 -	8.98	26.43	9.01	15.75	+0 -
by stage at financing:										
Seed	8.73	10.45	<sup>x</sup> 16.67	47.52	+91 *	6.47	7.17	5.36	7.20	-17 -
Early Stage	10.95	32.38	10.34	19.31	-6 -	8.78	30.26	8.03	13.38	-9 -
Expansion	10.47	17.28	15.56	27.47	+49 *	9.51	17.31	14.91	26.84	+57 *
Later Stage	18.59	22.88	15.73	15.52	-15 -	15.36	14.94	14.17	12.49	-8 -
<b>Later Rounds:</b>										
Round amount (\$m):	26.87	54.74	34.03	89.98	+27 ***	28.26	59.01	33.86	96.82	+20 *
by stage at financing:										
Seed	7.95	10.40	<sup>xx</sup> 32.59	125.70	+310 -	8.57	9.40	8.69	12.39	+1 -
Early Stage	19.58	41.28	21.56	35.66	+10 -	18.79	44.69	15.93	28.64	-15 -
Expansion	31.61	61.06	34.09	64.57	+8 -	32.27	63.21	33.68	65.50	+4 -
Later Stage	32.44	62.79	54.71	155.38	+69 ***	36.77	69.34	64.59	177.81	+76 ***
<b>N funding rounds</b>	2,588		2,434			2,108		1,924		

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Two-samples t-test is used to analyse difference of means.

<sup>x</sup>Note: Results are strongly biased by investments within the healthcare sector. Amunix Pharmaceuticals (83.6 \$m), Kriya Therapeutics (85.6 \$m), Lyell Immunopharma (493 \$m), Recode Therapeutics (80 \$m)

<sup>xx</sup>Note: 821.10 \$m investment in Sana Biotechnology (cell and gene therapy) as outlier. Without this investment the average amount would be 14.03 \$m.

<sup>9</sup> The general approach of one month has been changed by the following rationale: Using weeks instead of months increases the sample size which otherwise would be relatively small given the short crisis period. Furthermore, one month is expected as being not suitable given the velocity of the Covid-19 diffusion. On average, Covid-19 patients develop symptoms 5-6 days after the beginning of contagion (WHO 2020b). Therefore, fast changes due to new restrictions as an answer to increased infection rates are expected.

Table 7: Semi-logarithmic regression with full sample

	Investment Round amount (ln) – \$m					
	All Rounds		First Rounds		Later Rounds	
	(1)	(2)	(1)	(2)	(1)	(2)
Covid-19	.144*** (.038)	.367*** (.093)	.171*** (.061)	-.073 (.217)	.130*** (.048)	.394*** (.099)
Covid-19 x Seed		-.287* (.161)		.123 (.258)		-.276 (.318)
Covid-19 x Early Stage		-.284*** (.101)		.269 (.223)		-.392*** (.115)
Covid-19 x Expansion		-.241** (.108)		.326 (.262)		-.300*** (.115)
Round Status	-.528*** (.035)	-.527*** (.035)				
Syndicate	1.147*** (.038)	1.147*** (.038)	.863*** (.068)	.863*** (.068)	1.177*** (.050)	1.177*** (.050)
Business Angel	-.369*** (.037)	-.370*** (.037)	-.419*** (.050)	-.418*** (.050)	-.290*** (.054)	-.292*** (.053)
Government program	-.767*** (.102)	-.767*** (.101)	-1.738*** (.191)	-1.740*** (.191)	-.470*** (.117)	-.470*** (.117)
University program	-.429*** (.117)	-.428*** (.117)	-.282 (.192)	-.285 (.191)	-.650*** (.166)	-.641*** (.163)
Non-US VC	.449*** (.035)	.448*** (.035)	.243*** (.055)	.242*** (.055)	.512*** (.044)	.512*** (.044)
Core	.249*** (.034)	.249*** (.034)	-.023 (.056)	-.021 (.057)	.250*** (.047)	.253*** (.047)
Investment Stage:						
Seed	-.814*** (.075)	-.738*** (.088)	-1.278** (.121)	-1.292*** (.143)	-.931*** (.134)	-.861*** (.154)
Early Stage	-.590*** (.046)	-.515*** (.053)	-1.109*** (.104)	-1.169*** (.123)	-.513*** (.052)	-.407*** (.060)
Expansion	-.195*** (.047)	-.132** (.055)	-.746*** (.119)	-.820*** (.139)	-.168*** (.051)	-.088 (.059)
HQ in California	.780*** (.034)	.780*** (.034)	.580*** (.054)	.582*** (.054)	.864*** (.043)	.864*** (.043)
HQ in Massachusetts	.690*** (.053)	.695*** (.053)	.750*** (.098)	.752*** (.099)	.671*** (.062)	.680*** (.062)
HQ in New York	.446*** (.049)	.447*** (.049)	.323*** (.076)	.323*** (.076)	.481*** (.063)	.483*** (.062)
Constant	14.960*** (.072)	14.900*** (.074)	15.430*** (.151)	15.484*** (.163)	14.870*** (.083)	14.796*** (.085)
Industry Effects	YES	YES	YES	YES	YES	YES
R-squared	.298	.299	.273	.274	.297	.298
P-Value	.000	.000	.000	.000	.000	.000
Observations	8,802	8,802	2,909	2,909	5,893	5,893
Highest VIF <sup>1</sup>	2.165	2.167	4.372	2.369	2.098	2.255

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Standard errors are robust and shown in parentheses.

<sup>1</sup>Excludes the interaction terms.

Table 8: Semi-logarithmic regression without healthcare sector

	Investment Round amount (ln) – \$m without healthcare sector					
	All Rounds		First Rounds		Later Rounds	
	(1)	(2)	(1)	(2)	(1)	(2)
Covid-19	.130*** (.042)	.363*** (.107)	.180*** (.066)	-.114 (.234)	.101* (.053)	.398*** (.116)
Covid-19 x Seed		-.561*** (.192)		-.033 (.290)		-.549 (.520)
Covid-19 x Early Stage		-.295** (.116)		.343 (.240)		-.478*** (.134)
Covid-19 x Expansion		-.214* (.122)		.404 (.278)		-.292** (.131)
Round Status	-.596*** (.038)	-.595*** (.038)				
Syndicate	1.122*** (.042)	1.122*** (.042)	.765*** (.073)	.766*** (.073)	1.196*** (.057)	1.195*** (.057)
Business Angel	-.313*** (.039)	-.314*** (.039)	-.351*** (.052)	-.351*** (.052)	-.260*** (.058)	-.265*** (.057)
Government program	-.697*** (.122)	-.690*** (.122)	-1.752*** (.217)	-1.744*** (.217)	-.356** (.143)	-.351** (.142)
University program	-.443*** (.139)	-.441*** (.137)	-.158 (.223)	-.159 (.221)	-.756*** (.182)	-.749*** (.175)
Non-US VC	.360*** (.038)	.358*** (.038)	.161*** (.058)	.158*** (.059)	.411*** (.050)	.410*** (.050)
Core	.225*** (.037)	.225*** (.037)	-.078 (.060)	-.074 (.060)	.222*** (.054)	.224*** (.054)
Investment Stage:						
Seed	-1.096*** (.090)	-.935*** (.104)	-1.457*** (.136)	-1.421*** (.160)	-1.088*** (.202)	-.936*** (.228)
Early Stage	-.766*** (.053)	-.688*** (.061)	-1.157*** (.114)	-1.237*** (.135)	-.703*** (.060)	-.572*** (.070)
Expansion	-.323*** (.053)	-.267*** (.061)	-.773*** (.128)	-.867*** (.150)	-.276*** (.057)	-.198*** (.066)
HQ in California	.783*** (.037)	.786*** (.037)	.580*** (.058)	.582*** (.058)	.874*** (.048)	.875*** (.048)
HQ in Massachusetts	.571*** (.064)	.578*** (.064)	.663*** (.116)	.667*** (.116)	.549*** (.075)	.559*** (.075)
HQ in New York	.434*** (.052)	.435*** (.051)	.299*** (.081)	.299*** (.081)	.493*** (.066)	.493*** (.066)
Constant	15.134*** (.081)	15.071*** (.084)	15.596*** (.163)	15.665*** (.176)	14.970*** (.094)	14.886*** (.097)
Industry Effects	YES	YES	YES	YES	YES	YES
R-squared	.303	.305	.235	.237	.298	.300
P-Value	.000	.000	.000	.000	.000	.000
Observations	7,063	7,063	2,417	2,417	4,646	4,646
Highest VIF <sup>1</sup>	2.276	2.160	4.071	2.310	2.116	2.116

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Standard errors are robust and shown in parentheses.

<sup>1</sup>Excludes the interaction terms.

Table 9: Semi-logarithmic regression with winsorized dataset

	Investment Round amount (ln) – \$m with winsorized dataset					
	All Rounds		First Rounds		Later Rounds	
	(1)	(2)	(1)	(2)	(1)	(2)
Covid-19	.123*** (.036)	.358*** (.086)	.148*** (.054)	-.003 (.203)	.110** (.046)	.392*** (.092)
Covid-19 x Seed		-.298** (.150)		.053 (.239)		-.339 (.292)
Covid-19 x Early Stage		-.303*** (.094)		.168 (.208)		-.426*** (.108)
Covid-19 x Expansion		-.250** (.102)		.216 (.246)		-.309*** (.109)
Round Status	-.513*** (.032)	-.512*** (.032)				
Syndicate	1.060*** (.035)	1.060*** (.035)	.710*** (.058)	.710*** (.059)	1.107*** (.047)	1.107*** (.047)
Business Angel	-.377*** (.036)	-.378*** (.036)	-.417*** (.047)	-.417*** (.047)	-.297*** (.053)	-.299*** (.052)
Government program	-.618*** (.089)	-.618*** (.089)	-1.272*** (.139)	-1.273*** (.139)	-.419*** (.109)	-.418*** (.109)
University program	-.450*** (.116)	-.450*** (.116)	-.329* (.180)	-.331* (.180)	-.657*** (.166)	-.648*** (.162)
Non-US VC	.435*** (.034)	.435*** (.034)	.210*** (.051)	.209*** (.051)	.506*** (.044)	.506*** (.044)
Core	.269*** (.032)	.268*** (.032)	-.025 (.050)	-.023 (.050)	.267*** (.044)	.270*** (.044)
Investment Stage:						
Seed	-.772*** (.069)	-.693*** (.080)	-1.130*** (.107)	-1.131*** (.124)	-.887*** (.119)	-.798*** (.133)
Early Stage	-.550*** (.043)	-.471*** (.049)	-.963*** (.091)	-1.000*** (.106)	-.490*** (.048)	-.375*** (.056)
Expansion	-.186*** (.045)	-.121*** (.052)	-.646*** (.105)	-.695*** (.121)	-.167*** (.048)	-.085 (.056)
HQ in California	.740*** (.032)	.740*** (.032)	.536*** (.049)	.537*** (.049)	.827*** (.041)	.827*** (.041)
HQ in Massachusetts	.648*** (.051)	.653*** (.051)	.682*** (.088)	.684*** (.088)	.629*** (.059)	.639*** (.059)
HQ in New York	.419*** (.046)	.420*** (.046)	.285*** (.068)	.285*** (.068)	.455*** (.059)	.457*** (.059)
Constant	15.022*** (.067)	14.959*** (.069)	15.457*** (.134)	15.491*** (.143)	14.939*** (.078)	14.859*** (.080)
Industry Effects	YES	YES	YES	YES	YES	YES
R-squared	.303	.304	.258	.258	.304	.306
P-Value	.000	.000	.000	.000	.000	.000
Observations	8,802	8,802	2,909	2,909	5,893	5,893
Highest VIF <sup>1</sup>	2.165	2.167	4.372	2.369	2.098	2.255

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Standard errors are robust and shown in parentheses.

<sup>1</sup>Excludes the interaction terms.

Table 10: The impact of Covid-19 on lead VC 2-digit core investments

	Seed and Early Stage Investment Round amount (ln) – \$m								
	All Rounds			First Rounds			Later Rounds		
	Seed/Early Stage	Seed Stage <sup>1</sup>	Early Stage	Seed/Early Stage	Seed Stage <sup>1</sup>	Early Stage	Seed/Early Stage	Seed Stage <sup>2</sup>	Early Stage
Covid-19	.049 (.061)	.009 (.189)	.054 (.063)	.112 (.078)	.074 (.197)	.110 (.082)	.005 (.094)	-.081 (.455)	.012 (.096)
Core	.108** (.052)	.099 (.158)	.109** (.056)	-.077 (.074)	-.123 (.188)	-.072 (.082)	.183** (.082)	.616 (.406)	.153* (.085)
Covid-19 x Core	.157* (.089)	.015 (.308)	.162* (.094)	.223* (.130)	-.247 (.331)	.297** (.144)	.120 (.125)	.865 (.698)	.082 (.127)
Round Status	-.542*** (.042)	-.065 (.154)	-.584*** (.043)						
Syndicate	1.111*** (.052)	1.239*** (.177)	1.097*** (.055)	.935*** (.077)	1.048*** (.217)	.931*** (.084)	1.124*** (.083)	1.139*** (.389)	1.126*** (.086)
Business Angel	-.364*** (.044)	-.569*** (.144)	-.343*** (.047)	-.370*** (.055)	-.463** (.158)	-.355*** (.060)	-.327*** (.073)	-.321 (.365)	-.313*** (.076)
Government program	-1.162*** (.143)	-.533 (.627)	-1.216*** (.145)	-1.953*** (.218)	-1.171*** (.816)	-2.081*** (.225)	-.555*** (.187)	.626 (.987)	-.620*** (.185)
University program	-.440*** (.160)	.013 (.440)	-.542*** (.168)	-.370* (.220)	.404 (.429)	-.531** (.244)	-.616** (.292)	-.672 (.751)	-.570* (.313)
Non-US VC	.345*** (.046)	.505*** (.139)	.314*** (.049)	.222*** (.061)	.409*** (.148)	.152** (.067)	.423*** (.071)	.441 (.360)	.413*** (.072)
Seed	-.280*** (.077)			-.143 (.087)			-.561*** (.153)		
Covid-19 x Seed	-.028 (.139)			-.162 (.155)			.125 (.308)		
HQ in California	.797*** (.047)	.867*** (.149)	.801*** (.049)	.622*** (.061)	.736*** (.170)	.618*** (.066)	.957*** (.072)	1.117*** (.351)	.957*** (.073)
HQ in Massachusetts	.847*** (.072)	.913*** (.193)	.845*** (.078)	.799*** (.103)	.838*** (.232)	.808*** (.117)	.882*** (.098)	1.020** (.445)	.896*** (.101)
HQ in New York	.542*** (.061)	.653*** (.212)	.529*** (.064)	.331*** (.083)	.673*** (.237)	.280*** (.089)	.752*** (.090)	.509 (.638)	.756*** (.092)
Constant	14.459*** (.373)	13.957*** (1.505)	14.478*** (.374)	13.915*** (.264)	13.207*** (1.998)	13.944*** (.296)	14.776*** (1.064)	14.862*** (1.004)	14.762*** (1.066)
Industry Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	.293	.355	.293	.287	.409	.276	.291	.404	.289
P-Value	.000	.000	.000	.000	.000	.000	.000	.000	.000
Observations	4,654	503	4,151	2,344	363	1,981	2,310	140	2,170
Highest VIF	2.220	2.867	2.169	2.320	3.259	3.002	2.135	3.080	2.177

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Standard errors are robust and shown in parentheses.

<sup>1</sup> HC3 method for robust standard errors due to small sample size.

<sup>2</sup> HC2 method for robust standard errors due to very small sample size.

Table 11: The impact of Covid-19 on lead VC 4-digit core investments

	Seed and Early Stage Investment Round amount (ln) – \$m								
	All Rounds			First Rounds			Later Rounds		
	Seed/Early Stage	Seed Stage <sup>1</sup>	Early Stage	Seed/Early Stage	Seed Stage <sup>1</sup>	Early Stage	Seed/Early Stage	Seed Stage <sup>2</sup>	Early Stage
Covid-19	.059 (.060)	.112 (.183)	.049 (.062)	.124 (.078)	.154 (.191)	.110 (.081)	.017 (.091)	.009 (.440)	.008 (.093)
Core	.086 (.054)	.057 (.162)	.089 (.057)	-.115 (.078)	-.113 (.201)	-.115 (.086)	.189** (.077)	.465 (.318)	.170** (.080)
Covid-19 x Core	.141 (.091)	-.470 (.296)	.198** (.096)	.193 (.137)	-.615 (.343)	.327** (.150)	.095 (.123)	-.126 (.491)	.103 (.127)
Round Status	-.547*** (.041)	-.056 (.154)	-.587*** (.043)						
Syndicate	1.115*** (.052)	1.235*** (.177)	1.101*** (.055)	.923*** (.077)	1.059*** (.214)	.922*** (.083)	1.139*** (.078)	1.392*** (.351)	1.129*** (.081)
Business Angel	-.368*** (.044)	-.598*** (.144)	-.346*** (.047)	-.372*** (.055)	-.485** (.158)	-.357*** (.060)	-.336*** (.073)	-.440 (.383)	-.319*** (.076)
Government program	-1.164*** (.144)	-.600 (.624)	-1.214*** (.146)	-1.964*** (.216)	-1.190*** (.818)	-2.090*** (.225)	-.549*** (.188)	.453 (1.055)	-.609*** (.186)
University program	-.449*** (.161)	.006 (.442)	-.548*** (.169)	-.372* (.216)	.421 (.431)	-.532** (.243)	-.629** (.298)	-1.047 (.704)	-.574* (.316)
Non-US VC	.344*** (.046)	.515*** (.139)	.313*** (.049)	.221*** (.061)	.411*** (.146)	.150** (.067)	.420*** (.071)	.569 (.401)	.411*** (.072)
Seed	-.279*** (.077)			-.147* (.087)			-.556*** (.153)		
Covid-19 x Seed	-.029 (.140)			-.152 (.155)			.116 (.311)		
HQ in California	.798*** (.047)	.873*** (.149)	.805*** (.049)	.619*** (.061)	.758*** (.171)	.617*** (.066)	.959*** (.071)	1.043*** (.340)	.960*** (.073)
HQ in Massachusetts	.852*** (.072)	.907*** (.192)	.851*** (.078)	.801*** (.103)	.835*** (.231)	.812*** (.117)	.892*** (.098)	1.033** (.437)	.907*** (.101)
HQ in New York	.541*** (.061)	.676*** (.213)	.529*** (.064)	.332*** (.084)	.701*** (.238)	.282*** (.089)	.747*** (.090)	.244 (.658)	.755*** (.092)
Constant	14.457*** (.374)	13.902*** (1.566)	14.480*** (.374)	13.922*** (.226)	13.130*** (2.046)	13.953*** (.298)	14.765*** (1.066)	14.817*** (1.006)	14.767*** (1.066)
Industry Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	.292	.358	.293	.287	.418	.276	.291	.376	.290
P-Value	.000	.000	.000	.000	.000	.000	.000	.000	.000
Observations	4,654	503	4,151	2,344	363	1,981	2,310	140	2,170
Highest VIF	2.220	2.867	2.169	2.320	3.259	3.002	2.135	3.080	2.177

\*p<0.10; \*\*p<0.05; \*\*\*p<0.01; Standard errors are robust and shown in parentheses.

<sup>1</sup> HC3 method for robust standard errors due to small sample size.

<sup>2</sup> HC2 method for robust standard errors due to very small sample size.

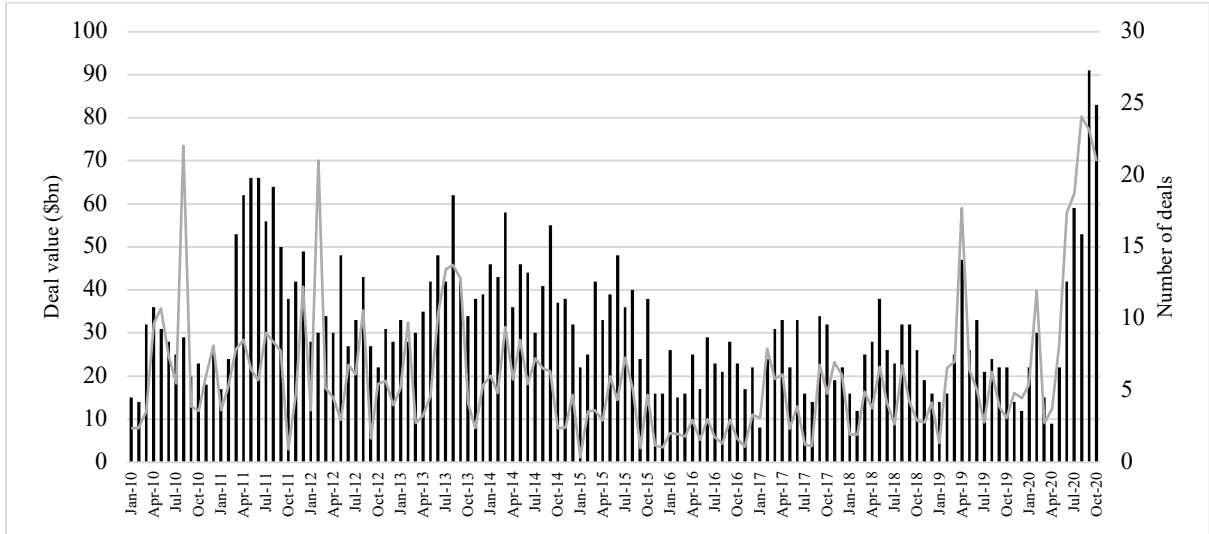


Figure 2: United States IPO Market (Bloomberg 2020)