Does the Government Have a Place in the VC Business? A Hungarian Case

By

Aron Bodisz

Submitted to

Central European University

Department of Economics

In partial fulfillment of the requirements for the degree of Economics MA

Supervisor: Sergey Lychagin

Budapest, Hungary and Vienna, Austria

2021

Abstract

In my thesis I study the role of state funds in the venture capital (VC) sector, how their funding structure differs from non-state backed (or private) VC funds' and the positive effects their special structure can potentially have on the start-up sector. I build on a theoretical model of Ewens, Jones and Rhodes-Kropf (2013) who use the principal-agent problem to show how the funding structures of venture capital funds influence their investment choices. I use their model to show why the state VC fund may overcome the principal-agent problem and non-government backed VC funds not. The model suggests that the state VC fund is willing to invest in lower net present value and/or riskier projects of firms. I take the theory to a company level data set and show empirical evidence to support its implications. I use a staggered diff-in-diff method to show that the performance of state VC-backed firms is significantly lower on average compared to their non-state VC-backed counterparts. I also show that on average the state VC fund invests in riskier firms. For that purpose I also use a regression where my outcome variable is a modified version of the index of dispersion. In light of these findings I argue that a state VC fund can be (socially) beneficial for a country as it might fund projects that are unattractive for private VC funds but still potentially generate a positive return.

Acknowledgements

I would like to thank my supervisor Sergey Lychagin for the consultations and for his suggestions that I benefited greatly from during the thesis writing process. I also want to thank Adam Szeidl and Miklos Koren for providing their data set and Andras Vereckei for preparing this data set for me.

Table of contents

List of Figures

List of Tables

1. Introduction

Following the 2007-2008 financial crisis, the European Union (EU) proposed many plans that could potentially boost the economies of member states. Among these plans there was one initiative that targeted venture capital (VC) funds. As Karsai (2017) notes, governments realized that the VC industry has a key role in creating innovative businesses and that the sector needs government support in order to expand. The VC funding scheme started in the 2007/2013 EU programming period and it has continued in the consecutive years. The windfall not only led to the increase of private VC funds' capital, but also new VC funds were able to form, partially relying on EU funds. Moreover, in 2009 the Hungarian government decided to set up its own state VC fund, the Szechenyi-tokealap kezelo, which has been operating under Hungary's Ministry of Finance. These series of interventions led to the booming of the (private) VC industry in Hungary. Beside the large number of private VC funds, the existence of a state VC fund became questionable as its purpose and potential contribution might not be evident. In my thesis I study the role of state funds in the venture capital (VC) sector, how their funding structure differs from non-state backed (or private) VC funds' and the positive effects their special structure can potentially have on the start-up sector. I argue that non-state backed VC funds have a funding structure where a principal-agent problem can arise between the investors and the managers of the VC fund. Using a theoretical model by Ewens, Jones and Rhodes-Kropf (2013) I show that due to government backing the state VC fund is not subject to the principal-agent problem. The theory implies that the principal-agent problem free funding structure allows state-backed VCs to invest in lower net present value (NPV) and/or riskier projects, which are proposed to them by entrepreneurs. To empirically support the two former implications I compare the performance and riskiness of companies that are funded by state-backed and non-state backed VCs. I show that due to these attributes of the state VC fund, its presence in the venture capitalist business is beneficial, because it can potentially help to increase the total welfare and the output of a country or a region throughout its operation. This paper is the first that studies the theoretical and empirical differences between state and private VCs, and the reasons why this specific form of government intervention might be more successful in achieving the stated goals of governments and the EU.

There are several reasons why Hungary is a perfect place to study this question. First, according to Karsai (2017) between 2011 and 2015 Hungary was among the top 5 countries in the EU where the most VC investments happened as a percentage of GDP. Second, the Szechenyi Tokealap-kezelo is fully state owned and has provided funds to around 100 small and medium-sized enterprises until 2016 since its operation started in 2011, resulting in enough data to perform sensible analysis. Finally, although Guo and Jiang (2013) also study the performance of VCs that use state money, their research is focusing on China which has a state capitalist system, as opposed to Hungary, that is by now well integrated in the EU's capitalist market.

The study of performance and productivity changes in companies that receive venture capital funding is not new to the literature. Chemmanur, Krishnan and Nandy (2011) use a large longitudinal U.S. database, and employ 3 different methods ('endogenous switching regression', fuzzy RD and propensity score matching) to estimate the effects and show that the overall efficiency of VC-backed firms is higher than those who do not receive funding. They find that those firms that get funded are more efficient prior to the funding than non-VC backed firms. They also show that both monitoring and screening play an important role in increasing the total factor productivity (TFP) of firms and similarly to Hellmann and Puri (2002) they document that VC backing helps firms to professionalize their managements. Furthermore, they estimate that VC backing leads to higher wages, which suggest that companies employ higher-quality workers after VC funding happens. Guo and Jiang (2013) study how venture capital investment contributes to the performance and R&D activities of firms in China. They use propensity score matching and find exactly the same in the case of China as Chemmanur, Krishnan and Nandy (2011) find in the case of the U.S. with a few key differences. First, China is an emerging economy so their findings suggest that VC funding has a productivity enhancing effect universally. Second, they further explore the factors that affect the value-added effects of VCs on entrepreneurial firms. Another well documented fact is that entrepreneurs are more likely to accept financing from high-reputation VCs than from low-reputation VCs (Hsu, 2004; Chemmanur, Krishnan and Nandy, 2011). Ewens, Jones and Rhodes-Kropf (2013) outline a game theoretic model where they study a principal-agent problem within the VC funding structure. What is new to their model compared to preceding research like Holmstrom and Ricart i Costa (1986) and Harris, Kriebel, and Raviv (1982) is that they explicitly consider prices. This allows them to measure the returns and risks of VC portfolios on the fund level using empirical asset pricing methods and find that the principal-agent problem has an effect on asset prices. Previous research has investigated the effect of state ownership on VC performance (for instance Guo and Jiang, 2013), but none of them studied completely state-owned VCs and/or state-owned VCs that operate in a capitalist market economy. This thesis tries to fill that gap by providing theory backed empirical evidence why a state VC can operate differently than private VCs.

I use the theoretical model from Ewens, Jones and Rhodes-Kropf (2013) to point out the theoretical differences between state VC-funds and non-state VC funds that are mainly based on their principal-agent problem argument. I also employ some of the empirical methods that Chemmanur, Krishnan and Nandy (2011) and Guo and Jiang (2013) use to study the performance differences between state backed and non-state backed VC funds. First, I run a staggered diff-in-diff regression where I regress performance indicator variables on the treated dummy interacted with time and a set of covariates, then I perform robustness checks by changing the baseline regression setup. To measure disparities in firm (and project) riskiness between the two types of funds, I run a regression where my outcome variable is a modified version of the index of dispersion, which I calculate from companies' sales. This approach is different from what Ewens, Jones and Rhodes-Kropf (2013) follow in their research, because they estimate risk on a fund level, while I estimate it on a company level.

I find that state VC-backed firms on average have a worse performance than non-state VC-backed firms. The difference is significant and indicates that the state fund is willing to accept lower performing firms into its portfolio. This former result remains robust even when I exclude the manufacturing industry that is the least balanced category in terms of treated-untreated observations. However, when I use an event-study method to check the distributions of the effects, I am unable to find a significant disparity between the performance of the two sets of firms in the first two post funding periods. I also find that the state VC fund invests in riskier companies that is also in line with the implications of the theory. This second result also remains robust when I reestimate the regression on the pre-funding period. Overall, I conclude that operating a state VC fund - which is not subject to the principal-agent problem - in a country can be beneficial, because it is willing to invest in lower NPV and/or riskier projects thus the output and welfare of the country can potentially increase. I also emphasize that this can only happen if the fund operates in a transparent and accountable way.

The remainder of my thesis is structured as follows: In Section 2 I outline the model by Ewens, Jones and Rhodes-Kropf (2013) and explain how its implications can be applied to my case. In Section 3 first I introduce my data set, then I show fund level statistics. I continue by showing which industries and technology sectors state and non-state VC funds' portfolios include and why this comparison is important. I conclude this section by discussing the main points of the summary statistics tables. Section 4 displays my main estimation results. I report and interpret the results of the regression estimations on performance differences, then I do the same for riskiness differences. Section 5 concludes the thesis and discusses some of its limitations.

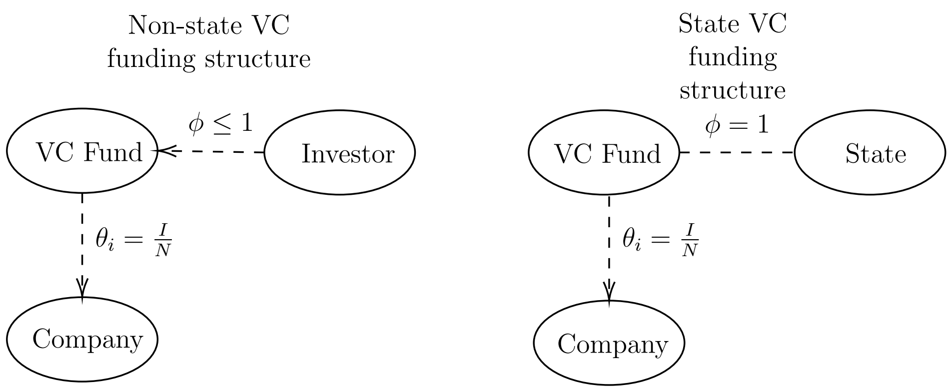
2. A principal-agent problem

My hypothesis is that a VC fund that is backed by the government can overcome a problem that is created by the relationship between the investors and the managers of the VC funds. To theoretically support it, I rely on a model developed in Ewens, Jones and Rhodes-Kropf (2013). In their paper they demonstrate how the principal-agent problem between VCs and investors influences how they choose investment projects. There are three participants in the model: venture capitalists, investors and entrepreneurs. The venture capitalist (the agent) needs to be compensated for the opportunity cost of his time. The investor (the principal) has a lack of information about the type of the VC or his actions, thus the VC's compensation depends on the returns of his chosen projects. It could happen that some VCs focus on a certain industry so they not only face investment specific idiosyncratic shocks but industry shocks as well. Even if the VC perfectly diversifies among industries, he will be unable to avoid that some projects may contain a correlated idiosyncratic risk component. Thus, they argue that prices should be low in venture capital and private equity even if there is a strong competition between VCs for projects. As a consequence, prices are lower than what is implied by a factor pricing model, such as the CAPM. This line of argument points out that VCs correctly use higher discount rates to evaluate projects, which leads to the fact that some projects are not taken even if these have a positive NPV based on factor risk alone.

In the model setup investors are willing to invest I dollars into a fund that has N projects in its portfolio. (This former assumption is in line with the reality, because VCs usually fund a limited number of companies due to monitoring capacity constraints.) Entrepreneurs have project ideas but they need help to realize the value of their ideas. With the help of VCs these project can generate a random output of $(1 + R_i)\theta_i$, where $\theta_i = I/N$ is the amount that VCs invest into each project. Each project bears risk that has two components: systematic (or market) and idiosyncratic risk. The return on a project also has two components: one component measures the net present value of the idea (in returns) and the other part simply measures the market return, like in a CAPM model. The risk-free asset has zero return in this model. Entrepreneurs and VCs have zero wealth, only investors do who are unable to decide if a project has a positive or negative NPV. VCs can perfectly assess the risks and returns of the projects (so they know the value of risk and return parameters as well) and there is perfect competition between them. Furthermore, VCs have no access to capital markets. Like in any other principal-agent model, the VCs exert an effort with a certain amount of opportunity cost. (The effort is unverifiable.) This means that VCs have to be compensated for their efforts by the investors. (The compensation incentivizes the VCs to provide effort.) All players are risk averse and require a compensation for the risk they hold, however because investors have enough wealth outside the fund that makes them well diversified, they only require returns for undiversifiable risk. The game has three stages. In the first stage the investor and the VC form a contract and they decide on ϕ, the fraction of the fund given to the VC. In the second stage, the VC negotiates with the entrepreneurs who receive $\theta_i = I/N$ dollars from the fund and in return they give up a part of their payoff schedule which they give to the VC. In the third stage, project values are realized and payoffs are distributed. It is very important to note that the optimal contract between the fund and the entrepreneur must depend on the output of the projects. The reasons why it should be specified this way is firstly because of principal-agent problem between the investor and the VC (investor-VC contract) and secondly because somehow risk has to be shared between the investor who can diversify and between the entrepreneur who cannot (VC-entrepreneur contract).

Without delving deeper into the model I show its main implications and discuss how it relates to my case. It can be shown that there is a solution for optimal shares (θ_i^*, ϕ^*) between the players. The optimal amount of ϕ^* (the fraction of wealth that investors provide for VCs) through the optimal share of θ_i^* (the fraction of project value that VCs get from entrepreneurs) depends on idiosyncratic risk. This is a key element of the model because this type of risk creates a wedge between gross returns on investment and net returns to investors. It means that due to this wedge, VCs use a higher interest rate to evaluate projects, which leads to an outcome where some positive NPV projects do not get funded. If there was no principal-agent problem probably a smaller wedge would still be present as long, as VC fees exist that are paid out of the gross returns. Ewens, Jones and Rhodes-Kropf (2013, p. 1863) also claim that ”If there were no principal-agent problem, the VC would still locate projects and negotiate with the entrepreneur for a share of the project, but the investor would rely on the VC to take actions in the investor’s best interest.” They also note that in that case (1) the VC’s payment depends on the project’s expected return and not on the realized returns; (2) the compensation still has to be larger than the cost of his effort, and (3) very importantly the VC holds no risk. However, they also emphasize that projects can still be more risky which require more effort from the VC to manage and monitor them. In return the investor provides all funding the VC needs, as it can negotiate a contract where it gets more compensation for his efforts. Therefore it does not discard relatively riskier projects if the investor is willing to provide a higher salary for the fund managers.

Figure 1: VC funding structures



Note: The figure is based on the model by Ewens, Jones and Rhodes-Kropf (2013)

The previous line of thought boils down to two important corollaries: if there is no principal-agent problem (1) lower positive NPV projects get funded and/or (2) more risky projects also get funded. This distinction between a scenario where the principal-agent problem is present and where it is not crucial in my case, because as my hypothesis states: the state fund (Szechenyi-tokealap kezelo) faces no principal-agent problem while the market-based funds do face it. As Figure 1 shows in the case of a state backed VC funding structure the state (or the Ministry of Finance) provides all the money the fund needs, no matter the risk or the magnitude of return on the projects. This assumption is not far from reality as the Szechenyi-tokealap kezelo is 100% state owned and its wealth is managed by Hungary's Ministry of Finance, but the fund has its own management and employees so it can be viewed as a separate entity. All the other funds operate according to a non-state backed VC funding structure. They have their own investor circles, managements, and employees, and they function and make investment decisions perfectly separately from each other. The main message of this theoretical discussion is that the principal-agent problem introduces inefficiencies in the VC funding market, therefore the state can intervene and establish a fund like Hungary did that is able to fund less profitable, lower NPV and riskier projects.

3. Data

3.1. Data and sample

My main data source includes the balance sheet items of all Hungarian firms for the years between 2009 and 2016. I merged my second smaller data set onto this former, which includes firms that received VC funding between 2011 and 2016. My combined data set contains 78 non-state funded firms and 83 state funded firms. Overall, I have a very balanced state funded - non-state funded observation ratio for each year (See Appendix A). There is a three-year period between 2009 and 2011 when funding does not occur in my sample, but this period is important because this allows me to measure the performance of firms up to 2-3 years before the first funding happens in 2011-2012. In most of the cases I could not observe the amount that a VC invested into a company so I chose to include only the beginning of their funding period.

VC funding is not a guarantee of success, in fact many start-up projects turn out to be a failure within a few years. However, a small number of luckier firms succeed and their investors usually exit them before the firm reaches a mature state. There are many ways of exiting a company, but in Hungary it is most commonly done via 'repurchase' or when the company's management buys out the VC investor(s). Sometimes investors also sell their share of the company to other investors. Top VC funded companies in the US and larger countries enter the stock market, but I have no knowledge about any company in Hungary that did that. Unlucky firms go bankrupt, especially start-ups whose ideas/projects turn out to be unsuccessful. This also happens relatively commonly in Hungary. In order to have a representative data set, I also collected data for those firms which were exited or went bankrupt. This way my sample is not subject to survival bias.

I cleaned and modified my data set to make it suitable for empirical analysis. I index some of the variables on a 2018 price level, and when it is possible I use these variables to calculate other variables like the sales growth of firms. To proxy for R&D I use one of the items from tax filing data where companies state how much they spent on developing immaterial goods. The problem with this variable that it is a rough measure of R&D since not all companies fill out that item in their filings. I use the number of employees (or average employee number by year) to proxy for firm size. To get labor productivity, I divide value added by the number of employees. Furthermore, I winsorized some of the variables that had very extreme outlier values, which affected less than 5% of the whole sample.

3.2. Fund level statistics

It is hard to empirically show that the principal-agent problem is present between the investors and managers of non-state funds. Nevertheless, indirect evidence (on the fund level) might help to support my claims according to which the state fund pays a higher wage to compensate its employees for overseeing higher risk projects (that require more attention and effort) and that the state fund has a higher capitalization relative to its size.

Table 1: Fund level statistics

	Non-state funds	**State fund**
t=2012		
Equity per worker (1000 HUF)	20,189	51,553
Average wage (1000 HUF)	6,755	11,951
t=2016		
Equity per worker (1000 HUF)	41,317	36,036
Average wage (1000 HUF)	7,836	11,194
t=2012-2016		
Equity per worker (1000 HUF)	41,673	40,969
Average wage (1000 HUF)	7,712	11,080

Note: Statistics above the dashed line are calculated in certain years, below the dashed line they are calculated on all observations between 2012 and 2016. Wages are price indexed on a 2018 price level. Data: CEU Microdata and the author's own data set

I calculated the equity per worker and average wages of the two types of funds for the first year when funding happens (by both types of funds) in my data set (2012) until the last year of my sample (2016). Equity per worker (EPW) can be thought of as a proxy for the backing (indirectly the ϕ parameter) that investors provide for the funds. By normalizing it with the fund size I get a measure with which I can compare funds to each other. As Table 1 indicates EPW was much larger for the state VC fund in 2012 compared to non-state VC funds it was two and half times larger, but by 2016 this difference declined. Nonetheless, as the average values of the equity per worker (on Table 1 under the dashed line) suggests, there is a negligible difference between the two types of funds on this dimension. I also compare VC funds based on how much their employees earn on average. As Table 1 shows average wages are indeed permanently higher in the state VC fund.

3.3. VC portfolios

While private VCs in my sample usually fund between 5-30 companies in the 2011-2016 time period, the Szechenyi Tokealap-kezelo funds around 80 companies in the same period. That is one of the attributes of the state VC fund that makes it different from the other funds. This is due to the fact that VCs are usually able to monitor well only a few companies so they have to limit their numbers[1]. As Table 2 shows, between 2011 and 2016 both types of funds almost had the same amount of firms by industry in their portfolios. It seems that the state VC fund invests more actively in the manufacturing industry than private VCs. There are some minor negligible differences, but the trend is clear: most of the funding happens in the IT and scientific research sectors, which are followed by the wholesale industry and the manufacturing industry. By using 2 digit TEAOR codes, I was able to look deeper into these broader industry categories and I found that IT, biotech and materials technology firms are in the biggest numbers among

[1]Recent research by Sannino (2020) shows that VCs limit their sizes and collectively fundraise too little. In the light of that finding the larger size might not necessarily indicate that the state fund is inefficient. It may rather imply that the state fund is able to extend its size closer to a socially optimal level.

the funded companies. In more moderate numbers, environmental technology, clothing, food and consulting companies are also present among the funded firms.

Table 2: VC portfolios by industry

TEAOR category	**Non-state funded**	**State funded**
Manufacturing	6	30
Water supply; sewerage, waste management and remediation activities	2	0
Construction	1	2
Wholesale and retail trade; repair of motor vehicles and motorcycles	8	5
Transportation and storage	0	1
Accommodation and food service activities	3	2
Information and communication	18	14
Financial and insurance activities	1	2
Real estate activities	4	1
Professional, scientific and technical activities	22	20
Administrative and support service activities	4	3
Human health and social work activities	1	3
Total	78	83

Note: The sample includes all firms that received VC funding between 2011 and 2016 in Hungary. *Data:* Author's own dataset.

The doubt that some of the companies included in the state VC's portfolio are politically connected may rightfully arise. I compiled a list that contains all Hungarian oligarchs, and based on that list and the articles of reliable news sites I searched for politically connected persons among the shareholders of the companies. During my search I used the Opten online data base. Even when I use the most loose categorization - which means that I consider a shareholder as politically connected based on even indirect evidence - I find that private VCs fund maximum around 8 and the state VC funds maximum around 5 politically connected companies. This means that the share of potentially politically connected firms in their portfolios are 10% and 6% for private VCs and the state VC respectively. When I look into private VC portfolios one-by-one, a pattern emerges. There is one non-state VC that funds 4 potentially politically connected firms, but this VC has also the largest portfolio in my sample. Other private VCs fund one or zero connected firms, but their portfolio size is substantially smaller. It has to be emphasized that I consider here the worst case scenario and yet the magnitude of the number of connected firms is small and around equal in the two (aggregate) portfolios. In the light of these findings I argue that when I make the assumption that the state VC and private VCs do not make investment decisions based on cronyism, I do not make a big mistake.

3.4. Summary statistics

As Table 3 shows, the means of variables in general seem to be very similar for both set of firms, while most of the differences arise from the fact that the state fund's portfolio includes few firms that are already in a mature state. (Large standard deviation for state funded variables also seem to reaffirm this.) For instance, it causes that the average firm age for state funded firms is 3 times larger than for non-state funded firms or the average firm size is 2.5 times larger for non-sate funded firms. On the other hand, key financial and operational statistics such as labor productivity, sales growth, leverage, ROE or ROS differ by much less. There are a few interesting features of these statistics. First, the mean ROEs and ROSs are negative which is due that even after winsorization some larger negative observations remained in the sample that decreased the mean of these variables. This is not a problem because, my sample also includes companies that went bankrupt and their ROEs and ROSs usually remain low or even negative for a few years before they go bankrupt. Second, it might be surprising that there is a fourfold difference in the standard deviations in total sales between state and non-state funded firms. This already can be a telltale sign that the state fund has companies in its portfolio that can be viewed as more risky based on sales variance. Third, in some cases the equity is negative. When a company becomes highly unprofitable retained earnings usually become negative and because equity contains retained earnings as one of its components, it can decrease the equity of the firm by so much that it becomes negative.

Table 3: Summary statistics of VC backed firms

Non-state funded

Variable	Obs	Mean	Std. dev.	Min	Max
Total assets (1000 HUF)	192	367,252.3	460,140.6	0	2,995,812
Total equity (1000 HUF)	191	220,239.2	262,326.4	-412,494	1,571,790
Total sales (1000 HUF)	182	102,609.9	190,379.2	0	1,141,030
Firm size	166	7.13	9.67	0	58
ROS	112	-1.23	2.43	-9.73	3.13
ROE	191	-0.33	1.08	-8.08	4.65
Labor productivity	144	3,757.2	29,284.2	-94,885.7	279,677
R&D (1000 HUF)	63	10,898.1	19,666.7	0	241,670
Leverage	152	0.36	0.44	0.0002	3.32
Sales growth	86	0.59	1.38	-1	5.99
Firm age	192	2.26	2.24	0	13

State funded

Variable	Obs	Mean	Std. dev.	Min	Max
Total assets (1000 HUF)	232	454,534.5	795,828.5	0	8,961,668
Total equity (1000 HUF)	230	204,740.2	261,706.5	-89,260	1,855,591
Total sales (1000 HUF)	227	325,667.8	873,388.1	0	10,700,000
Firm size	221	18.63	38.25	0	357
ROS	195	-0.64	1.62	-9.54	1.47
ROE	229	-0.29	2.2	-7.39	8.46
Labor productivity	210	3,822.1	19,231.1	-105,247.3	171,999.7
R&D (1000 HUF)	135	14,042.9	57,463.9	0	405,074
Leverage	205	0.4	0.29	0.002	2
Sales growth	177	0.66	1.78	-1	9.37
Firm age	232	9.06	9.8	0	59

Note: Statistics are calculated on all observations between 2009 and 2016. Some variables are winsorized and/or price indexed on the 2018 price level. Data: CEU Microdata and the author's own data set

As Table 4 shows, average ROSs and ROEs are all negative in each presented year for both types of companies, but the difference between them is never highly significant.

The gap between ROSs is smaller in 2012 and gets larger in 2014 and 2016. The opposite is true for the ROEs, where the difference steadily declines as years go forward and by 2016 the gap between them totally eliminates.

Table 4: T-test for the performance and R&D of state VC funded and non-state VC funded firms

	State funded	**Non-state funded**	**Difference**	**t-Statistics**	**z-Statistics**
t = 2012					
ROS	-0.387	-0.339	-0.048	-0.108	-1.030
ROE	-0.598	-0.030	-0.340	-0.807	-0.857
Sales growth	0.110	-0.106	0.215	0.582	-0.730
Labor productivity	5,834.561	701.302	5,133.259	1.652	-1.780*
R&D	0	20,393.5	-20,393.5	-	-
t = 2014					
ROS	-0.561	-1.627	0.886	1.907*	-0.955
ROE	-0.237	-0.263	0.248	0.151	-1.592
Sales growth	0.686	0.685	.001	0.002	0.718
Labor productivity	1,239.246	-2.607	1,241.853	0.301	-1.795*
R&D	27,245.38	15,353.45	11,891.92	0.650	0.471
t = 2016					
ROS	-0.889	-1.492	0.603	1.314	-1.224
ROE	-0.179	-0.179	0.000	-0.004	-0.429
Sales growth	0.647	0.451	0.196	0.619	0.200
Labor productivity	4,980.66	7,097.085	-2,116.425	-0.315	-0.315
R&D	4,145.5	27,926.43	-23,780.93	-2.867***	2.097**

*Note: All observations are at the firm-year level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Statistical significance for differences of means and medians differences correspond to t-tests and rank-sum tests, respectively. Data: CEU Microdata and the author's own data set*

Mean sales growth is larger for state-backed firms in each year, but the difference is never significant. Labour productivity also seems to be larger for state VC-backed firms in 2012 and 2014, but this disparity between them decreases with time and is never highly significant. The varying results for R&D come from the fact that companies fill out this item on their statements in an ad hoc way. Nevertheless, it remains my best proxy to measure R&D activity. For 2012 there are too few observations to draw any conclusions, but for 2014 and 2016 I measure substantial differences between the two sets of firms. This difference is highly significant in 2016 when non-state VC-backed firms seemed to spend outstandingly more on research and development than their state VC-backed counterparts. To test whether the results are affected by outliers or drawn from distinct distributions I perform the Wilcoxon test (on the median). These results indicate that my results are robust to outliers, and at the same time indicate that the distributions from which these variables are drawn are similar to each other, and do not change with time.

4. Empirical evidence

In this section I empirically test the two main implications of the theory that I outlined in Section 2: (1) whether the state fund accepts firms into its portfolio that have potentially lower NPV projects and perform worse and (2) whether these companies have potentially riskier projects as their peers in a market-based fund.

4.1. Does the state VC fund accept worse performing firms into its portfolio?

To measure the performance difference between state VC-backed and non-state VC-backed firms, I run a fixed effects regression on my main performance indicating variables that include return on sales, return on equity, sales growth and labor productivity. VC funding is distributed over time hence I allow for the staggering of the events in my regressions. I take the approach suggested by Petersen (2009) who recommends using fixed effects and clustered standard errors in panel data models that use corporate financial data. I also include firm, year and industry fixed effects, furthermore I cluster standard errors on a firm level. Moreover, since my aim is to estimate differences between firms that ever received VC funding, I condition on this criteria and only run the estimation on these firms. Thus my regression takes the following form:

$$\begin{aligned} Y_{ijt} = \alpha_i + \lambda_t + \beta_j + \gamma X_{ijt} + \delta_1 VCAfter_{ijt} \\ + \delta_2 VCAfter_{ijt} \times VCState_{ijt} + \epsilon_{ijt} \end{aligned} \quad (1)$$

, where α_i denotes firm fixed effects, λ_t year fixed effects, β_j industry fixed effects, X is a matrix of covariates that include leverage, firm size and firm age. Finally, $VCAfter$ stands for the dummy that indicates if a company is currently VC funded and $VCState$ is also a dummy that indicates if the VC funding is provided by the state fund.

As Table 5 shows, the performance of companies increase after they receive funding, although this effect is not significant for ROS and sales growth. However, for ROE and labor productivity - which are the two most meaningful measures of performance and productivity - I estimate a significant positive effect. The significance of this effect might be attenuated by the fact that between 2011 and 2015 a large portion of private VCs chose to accept a 'seed fund status' in exchange for EU funds , which means that some of them had to start investing in start-ups that were not among their targeted firm groups previously in order to comply with the funding requirements (Karsai, 2017). The coefficient δ_2 captures the effect of state VC funding (relative to private VC funding), and, as the estimates indicate, this effect is significantly negative in all cases except for sales growth.

Table 5: The performance of non-state VC-baked firms and state VC-backed firms - a staggered DID approach

	(1)	(2)	(3)	(4)
	ROS	ROE	Sales growth	Labor productivity
VCAfter	0.787	0.828*	0.270	6,446**
	(0.549)	(0.455)	(0.250)	(2,856)
VCAfter × VCState	-1.195**	-1.028**	-0.278	-7,542**
	(0.559)	(0.475)	(0.370)	(3,131)
Leverage	-0.151	0.674***	-0.151	-488.1
	(0.295)	(0.228)	(0.324)	(1,516)
Firm size	-0.00286	0.00603**	0.00403	-17.01
	(0.00188)	(0.00278)	(0.00563)	(12.07)
Firm age	0.0856**	0.0617	-0.108**	889.0*
	(0.0373)	(0.0499)	(0.0449)	(475.2)
Constant	-1.080***	-1.997***	1.240**	7,318***
	(0.276)	(0.490)	(0.518)	(2,490)
Observations	449	536	375	495
R-squared	0.083	0.118	0.063	0.717
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

*Note: Robust standard errors in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Data: CEU Microdata and the author's own data set.*

The magnitude of state funding effects are roughly the same as VC funding 'receivement' effects which implies that if a firm gets funded by the state VC fund, its performance is not expected to improve as much as if they got funded by a non-state fund. These results remain robust even after I exclude the manufacturing industry from the sample, which is the only industry category where a notable imbalance exists in VC portfolios, as Table 2 suggested (See Appendix B). At the same time, this does not mean that these firms do not do better than firms that do not receive any funding at all. These companies seem to all have lower NPV projects so their performance does not increase greatly ex post, but investing in them is still potentially ex ante profitable for the state fund.

Although my main intent is to estimate cumulative treatment effects as I did in the previous regression, I also want to check how the effects are distributed before and after funding happens and whether the parallel trends assumption holds. For this purpose, I estimate a regression with an event study setup. First, I find that the parallel trends assumption holds as none of the pre-funding period dummies are highly significant (See Appendix B). Second, in the post-funding periods I get similar results as in my first regression. The VC funding dummies are positive, while their interaction with the state VC dummy is negative in both post-funding periods. Although they are not significant, their positive magnitude indicates that VC funding affects firm performance positively, but if the funds originate from the state fund, performance does not increase that much from the pre-funding level.

4.2. Does the state VC fund accept riskier firms into its portfolio?

As theory suggests, the state VC should be willing to accept even riskier projects than private VC funds. For this, I have shown indirect evidence in the summary statistics section, where the variability of sales for state VC funded firms was higher (See Table 3). To measure whether the state VC fund really accepts riskier firms into its portfolio, I calculate the index of dispersion for companies' log sales. My approach is different from that of Ewens, Jones and Rhodes-Kropf (2013) who utilize empirical asset pricing methods to study the riskiness of VC portfolios. Their data comprises portfolio positions and returns of VC funds, thus they measure the riskiness effect on the fund level and not on the company level.

I reckon that the variability of sales is a good proxy for riskiness, because if there is a stable demand for the company's product, the variability should be low. In contrast, if sales variability is high, it indicates that the firm might have had a more ambitious, riskier product/service idea that does not have a stable market. The reason why I use index of dispersion instead of simple variance estimation is because the number of observations differ for firms, consequently in some cases I compute the variance on more time periods than for other firms. The index of dispersion takes this difference into account and normalizes the variances, thereby they become comparable. The conventional index of dispersion formula is simply the fraction of the variance and the mean. The problem with that formula is that it is designed for symmetric distributions that has a low skewness. My observations are highly skewed, so instead of the simple formula that I just described, I use an alternative version that takes skewness into account. This alternative formula (that uses a linear loss function instead of a quadratic one) for the index of dispersion is written as:

$$ID = \frac{1}{n} \frac{\sum_j |m - x_j|}{m} \tag{2}$$

, where n is the sample size, m is the sample median and the sum is taken over the whole sample.

I calculate it for each firm in my sample, then I regress it on the $VCState$ dummy. I include industry dummies in each regression and in the second specification I also use control variables that are the averages of panel variables. As Table 6 presents, the $VCState$ dummy is significant and positive in both cases, which indicates that on average the state VC fund is willing to accept riskier firms into its portfolio. Even after controlling for firm characteristics, I still get a significant and positive coefficient for the $VCState$ dummy. Given that the unconditional mean index of dispersion for non-state VC funded firms is around 0.054 and for state VC funded firms it is around 0.081, the estimated differences imply that the state VC fund is inclined to fund companies that are $60 - 80\%$

riskier than those for which their private peers provide funding.

Table 6: The riskiness of non-state VC-baked and state VC-backed firms

	(1) Index of dispersion	(2) Index of dispersion
VCState	0.0424***	0.0340**
	(0.0142)	(0.0152)
Average firm size	-	-0.000167
		(0.000229)
Average firm age	-	-0.00132
		(0.00110)
Average leverage	-	-0.0220
		(0.0222)
Constant	0.00514	0.155
	(0.0693)	(0.170)
Industry dummies	YES	YES
Observations	161	154
R-squared	0.340	0.390

*Note: Standard errors in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Data: CEU Microdata and the author's own data set.*

I do a robustness check and estimate the same regression in firms' pre-funding periods (See Appendix C). I find that state VC-backed firms are riskier on average, however, not significantly riskier than non-state VC-backed firms. I must emphasize that the number of observations decreases greatly when I drop post-funding periods, but this result indicates that the state VC fund picks ex-ante firms that are sometimes riskier than firms that non-state VC funds pick. This result is not quantitatively different from the one in Table 6. As research showed (for example Brown, Gredil & Kaplan, 2019) investors can usually see through earnings or other types of manipulation, thus it is plausible to assume that VC funds, either state or non-state can assess the riskiness of a project well ex-ante.

5. Conclusions and limitations

The fact that states have VC funds is a relatively new phenomenon not just in Hungary but in Europe as well. In my thesis I studied the role of the Hungarian state fund in the country's VC sector, how it differs from private VCs and whether it has any positive contribution to the start-up sector. I outlined a theory about the functioning of state VC funds and non-state (or private) VC funds that I based on Ewens, Jones and Rhodes-Kropf (2013). The theory indicates that because state VC funds do not face the principal-agent problem, they are able to fund lower NPV and riskier projects than their non-state funded counterparts. The time period that elapsed since the establishment of the state fund (Szechenyi tokealap-kezelo) allowed me to make meaningful comparisons and verify the predictions of the theory. First, I investigated whether the state VC fund invests in lower performing companies using performance proxies. By using a staggered DID setup, I was able to document significant differences between the performance of the two sets of firms in favour of private VC-backed companies whose performance was higher on average. To check whether the state VC funds riskier companies I estimated a regression on a modified version of the index of dispersion and I found that the Szechenyi tokealap-kezeo accepts significantly riskier firms into its portfolio. These findings are all in line with the theory.

The results of my thesis support the idea that state backed VC funds are less picky when it comes to funding start-ups and growth firms with publicly beneficial projects. The empirical findings in this study have shown that private VCs kept targeting high potential and relatively low risk firms even after they had received EU funding for the purpose to broaden their portfolio with more publicly beneficial start-up projects. As I argued, this behaviour is a consequence of their funding structure which is subject to the principal-agent problem. The main finding of this thesis is that because state backed VCs are not subject to the principal-agent problem, they can be successful in funding firms' projects that do not necessarily have a high return and/or low riskiness, but could be beneficial for society.

The generalisability of these results is subject to certain limitations. First, cross-country research is needed to investigate whether these results hold in other European countries where state VCs were established (Karsai, 2017). Second, the welfare gains that the presence of a state VC fund could potentially generate are not quantified in this paper. Third, I do not know how the application mechanism works between the firms and the VCs. I am unable to identify whether a firm or an entrepreneur initially tries to seek funding from non-state VC funds and if she gets rejected, then she starts to look for funding at the state VC fund. Finally, up to now, previous studies have shown that entrepreneurs tend to favor VCs that have a high reputation, because they provide better services (for instance, they have better connections to suppliers and potential consumers) for firms (Chemmanur, Krishnan and Nandy, 2011). Obviously it is a hard task to rank VCs objectively, however there are some studies that attempt to do it (for instance Nahata, 2008). Unfortunately, in order to be able to create these performance based rankings, I would need to know for instance for how much companies are acquired after they are exited. A richer data set that contains how much VCs invest in companies, how much return they earn during the funding period, and for how much they sell their share of the company would help to extend the analysis in that direction.

References

Brown, G. W., Gredil, O. R., & Kaplan, S. N. (2019). Do private equity funds manipulate reported returns? *Journal of Financial Economics*, *132*(2), 267-297.

Chemmanur, T. J., Krishnan, K., & Nandy, D. K. (2011). How does venture capital financing improve efficiency in private firms? a look beneath the surface. *Review of Financial Studies*, *24*(12), 4037–4090.

Ewens, M., Jones, C. M., & Rhodes-Kropf, M. (2013). The price of diversifiable risk in venture capital and private equity. *Review of Financial Studies*, *26*(8), 1854–1889.

Guo, D., & Jiang, K. (2013). Venture capital investment and the performance of entrepreneurial firms: Evidence from china. *Journal of Corporate Finance*, *22*, 375–395.

Harris, M., Kriebel, C. H., & Raviv, A. (1982). Asymmetric information, incentives and intrafirm resource allocation. *Management Science*, *28*(6), 604–620.

Hellmann, T., & Puri, M. (2002). Venture capital and the professionalization of start-up firms: Empirical evidence. *The Journal of Finance*, *57*(1), 169–197.

Holmstrom, B., & Costa, J. R. I. (1986). Managerial incentives and capital management. *The Quarterly Journal of Economics*, *101*(4), 835.

Hsu, D. H. (2004). What do entrepreneurs pay for venture capital affiliation? *The Journal of Finance*, *59*(4), 1805–1844.

Karsai, J. (2018). Government venture capital in central and eastern europe. *Venture Capital*, *20*(1), 73-102.

Nahata, R. (2008). Venture capital reputation and investment performance. *Journal of Financial Economics*, *90*(2), 127-151.

Sannino, F. (2020). Sorting and fund size in the venture capital market. *Working paper*.

Appendix

A. Test of the overlap assumption

Table A1: Number of observations by year

	Year					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Non-state funded	3	10	13	37	61	68
State funded	0	12	26	50	71	73

Data: The author's own data set.

B. Robustenss checks: Does the state VC fund accept worse performing firms into its portfolio?

To check for the parallel trend assumption and to measure the magnitude of the treatment effects after firms receive VC funding, I estimate the following regression:

$$\begin{aligned} Y_{ijt} &= \alpha_i + \lambda_t + \beta_j + \gamma X_{ijt} \\ &+ \sum_{s=0}^{-3} \delta_1^s VCBefore_{ijt} + \sum_{s=0}^{-3} \delta_2^s VCBefore_{ijt} \times VCState_{ijt} \\ &+ \sum_{s=1}^{2} \delta_3^s VCAfter_{ijt} + \sum_{s=1}^{2} \delta_4^s VCAfter_{ijt} \times VCState_{ijt} + \epsilon_{ijt} \end{aligned} \tag{3}$$

As in regression (1) α_i denotes firm fixed effects, λ_t year fixed effects, β_j industry fixed effects, X is a matrix of covariates that include leverage and firm size. It is also important to note that with this more restrictive setup I estimate on less observations.

Table A2: The performance of non-state VC-baked firms and state VC-backed firms - an event study approach

	(1) ROS	(2) ROE	(3) Sales growth	(4) Labor productivity
VCBefore(-3)	0.630	1.478	1.811	-440.7
	(1.102)	(1.790)	(1.554)	(6,529)
VCBefore(-3) × VCState	-0.651	-1.722	-1.351	-7,859
	(1.093)	(1.777)	(1.584)	(8,456)
VCBefore(-2)	-0.613	0.988	1.511	-2,753
	(0.731)	(1.592)	(1.306)	(4,051)
VCBefore(-2) × VCState	0.613	-1.787	-0.574	-1,820
	(0.694)	(1.560)	(1.373)	(4,125)
VCBefore(-1)	-1.001	-0.352	2.769**	126.1
	(0.958)	(2.434)	(1.368)	(3,877)
VCBefore(-1) × VCState	1.358	-0.228	-2.082	-1,965
	(0.951)	(2.563)	(1.371)	(4,281)
VCBefore(0)	-0.227	1.566	2.850*	987.4
	(0.672)	(2.125)	(1.507)	(4,029)
VCBefore(0) × VCState	0.0477	-2.442	-2.384	-4,894
	(0.696)	(2.206)	(1.509)	(4,433)
VCAfter(1)	0.989	1.603	2.145*	8,956**
	(0.722)	(2.205)	(1.262)	(4,023)
VCAfter(1) × VCState	-1.244*	-1.892	-1.543	-14,065***
	(0.703)	(2.254)	(1.302)	(5,273)
VCAfter(2)	0.987	2.006	2.075*	5,303**
	(0.765)	(2.184)	(1.233)	(2,326)
VCAfter(2) × VCState	-0.907	-2.353	-1.286	-4,665
	(0.733)	(2.207)	(1.213)	(5,232)
Leverage	0.0391	0.533*	-0.0794	-598.1
	(0.340)	(0.303)	(0.362)	(2,123)
Firm size	0.00305	0.00406	0.0137	-20.29
	(0.00630)	(0.00409)	(0.0152)	(15.40)
Constant	-0.840**	-1.114	-0.776	15,900***
	(0.394)	(0.792)	(0.649)	(2,365)
Observations	369	442	313	414
R-squared	0.167	0.182	0.094	0.754
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

*Note: Robust standard errors in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Data: CEU Microdata and the author's own data set.*

Table A3: The performance of non-state VC-baked firms and state VC-backed firms - a staggered DID approach (manufacturing industry excluded)

	(1)	(2)	(3)	(4)
	ROS	ROE	Sales growth	Labor productivity
VCAfter	0.756	0.840	0.132	6,980***
	(0.640)	(0.529)	(0.217)	(2,643)
VCAfter × VCState	-1.421**	-1.183**	-0.139	-10,370***
	(0.657)	(0.554)	(0.403)	(3,012)
Leverage	-0.381	0.761***	-0.300	-1,649
	(0.239)	(0.240)	(0.306)	(1,164)
Firm size	-0.00491	0.00771***	0.00714	-7.378
	(0.00364)	(0.00246)	(0.00858)	(8.087)
Firm age	0.133**	0.0845	-0.137**	1,122**
	(0.0532)	(0.0702)	(0.0608)	(561.4)
Constant	-1.350***	-1.899***	1.292**	5,118**
	(0.333)	(0.563)	(0.630)	(2,329)
Observations	322	399	270	365
R-squared	0.107	0.094	0.075	0.816
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

*Note: Robust standard errors in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Data: CEU Microdata and the author's own data set.*

C. Robustness check: Does the state VC fund accept riskier firms into its portfolio?

Table A4: The riskiness of non-state VC-baked and state VC-backed firms in the pre-funding period

	(1) Index of dispersion	(2) Index of dispersion
VCState	0.0144	0.0108
	(0.0228)	(0.0204)
Average firm size	-	-0.000182
		(0.000232)
Average firm age	-	-0.00167
		(0.00122)
Average leverage	-	-0.0267
		(0.0303)
Constant	0.00514	0.173
	(0.0763)	(0.170)
Industry dummies	YES	YES
Observations	93	79
R-squared	0.453	0.670

*Note: Standard errors in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Data: CEU Microdata and the author's own data set.*