Venture Capital and the Innovative Power of a State: Econometric Study Including Google Data

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Abstract

This article focuses on venture capital investments and the innovative power of a state defined by its public infrastructure. The economic implications are evaluated by estimating several panel regression models. The novelty is twofold: on the one hand the research approach and on the other hand the new data set. The data ranges from 1995 to 2014 and consists of 10 European countries plus the US and Canada. For the first time we include Google search data on Venture Capital. The results show a significant increase in Venture Capital is mainly determined by economic conditions such as real GDP growth. The impact of the innovative power of a state is not significant. We find that Google data is positively related and significant in respect to Venture Capital investments too. Consequently, we confirm that private business investments cannot be created by government policy alone rather via solid macroeconomic conditions.

1. Introduction

Economic growth and innovation is closely intertwined since centuries. The degree of innovation and technological progress is the most important ingredient for economic output according to growth theory. Since the year 2000, the European Council implemented the Lissabon-strategy, which aims the European Union (EU) to be the most competitive and dynamic know-how-based economic area in the world until 2010 [1]. In 2002 the European heads of state specified this strategy and focused in their realization in particular on research and development including innovations as a core aspect. However, it turned out that this objective has been too ambitious, and the developments were largely disappointing. Hence, there is a politico-economic debate about more realistic strategies that really work [2,3]. In 2010, it was visible that the Lissbon-strategy of the EU has failed.

Then with the onset of the European Debt Crisis, the EU has updated the Lissbon-strategy and they now call it 'Strategy 2020' [4]. The new strategy has mainly the same targets however, it is more realistic and it defines sub-targets including a monitoring process for all achievements. Yet, it is questionable whether the Strategy 2020 will work this time.

This paper sheds new light on these issues in particular on the linkage between the financing of innovation and economic growth. We approach this debate by studying the growth of Venture Capital (VC) investments and attempt to explain this dynamic by public infrastructure variables on the one hand and the overall macro-economy on the other hand. There is a second issue why this research is of importance: since two decades, it seems that innovation and economic growth in Europe is lagging behind the US. Even more problematic this gap is growing with the digital economy and the recent technological advancements, such as industry 4.0.

However, following the 'real origin' of past and recent ingenuity and innovation reveals a paradox: many crucial inventions and innovations have its origin in the EU. One example is the World Wide Web that was developed in Cern, Switzerland. Another example for innovative excellence is the audio compression (mp3), which was a result of research in the *Fraunhofer Institut* in Germany [5]. This all begs the question why the EU continues to loose its position in comparison to the USA? Until now, the details of this trend are unclear. Hence there is a debate about the real influencing factors. Some argue that the innovation statistic is flawed and biased because it only counts the market ready products and not the spatial origin of innovation [5].

In this paper, we study these issues in an econometric model. We estimate Venture Capital (VC) that is a potential driver of the financing of private business innovation and compare it to the innovation power of states. This research elaborates whether the innovation power of a country affects the volume of VC, which is reinforcing further investments and economic growth. Furthermore, we consider certain differences across countries and time to obtain a better understanding of the underlying success factors.

The following paper is structured in four parts. In section 2, we provide a brief literature review. Section 3 introduces the econometric methodology and data. Finally, we discuss our findings in section 4. Section 5 concludes the paper.

2. Literature Review

In general, Venture Capital (VC) has different forms. First, VC is a financial intermediary, which means that it takes investors' capital and invests it directly in portfolio companies. This is similar to a bank, which takes money from depositors and afterwards loaning it to businesses and individuals [6]. The second type of VC is private equity. VC that invests only in private companies, which means that once the investments are made, the companies cannot be traded on a public exchange. Therefore VC and private equity is considered to be alternative investments and is contrary to traditional investing in stocks and bonds. The third form of VC is when the fund takes an active role in managing and monitoring companies. Without that, VC would only provide capital and its success would be entirely due to its ability to choose investments. Although, the comparative advantage of VC is that the investor can support a new business, very often VC investors take at least one position on the board of directors. This allows the VC investor to provide advice at the management level [7]. The fourth type of VC is the provision of financial sources to undertake as soon as possible a sale or an initial public offering (IPO). This form of VC is typical for rather small businesses, but they only do so when these small enterprises have a realistic chance to grow enough to become a large company in a few years [8]. Closely linked to this form is the special funding of new business ideas [9].

There is also literature on the innovation power of a state that will be studied in our paper. Luecke and Katz [10] define innovation as a process that is based on the one hand on the private initiatives, such as a new method, a new product or process and on the other hand by the usage of public infrastructure, such as high skilled workers, low costs to setup a new business and so on. It is evident that Luecke and Katz have Schumpeter's definition in mind, who defines economic innovation by four features [11]. First, innovation is the introduction of either a new or better quality product. Second, the introduction of a new method founded upon a scientifically new way. New market access is the third feature of innovation. And finally, the fourth feature is the conquest of new

resources, such as new crude materials or half-manufactured goods. According to Schumpeter, each innovation transforms and destroys the old ways of doing and replaces them by new. He calls this process a *creative destruction*. The innovation power of a state or a region is thus determined by the overall public infrastructure that supports these four innovation features. Of course, this literature also distinguishes between product innovation, we already talked about, and the so-called end-user innovation. The latter, is based on individual or company specific inventions for its own needs [12].

3. Data and Methodology

We use a new dataset for this econometric study. It has been collected from different databases via FactSet a financial data provider. Some time series data are from OECD, IMF, Oxford, World Intellectual Property Organization (WIPO), or from the sources provided by countries directly. The paper makes use of a panel containing 12 countries and the time period between 1995 and 2014. The panel data merges all information from all countries and years.

We estimate the impact of VC in respective to real GDP and several state related variables. Hence, we attempt to explain VC by two main factors: a) the endogenous economic development and b) the state related innovation potential determined by the public infrastructure. We state the hypothesis that both the overall economy and the state related infrastructure for innovations are essential for VC investments.

It is already hard to gather data on VC, but it is even harder to find consistent data on the innovative power of states. No international organizations, such as the World Bank or the OECD have all the data we need; hence we combine data from different sources. Due to the lack of a variable that measures all aspects of the innovative-power of states, we build our own innovation-indicator. We label it the *Innovative Power Index* (IPI) and it covers the following parameters: number of patents, number of startups, costs of startups, startup density, the number of people with tertiary education in respect to the labor force, and expenditure per student in relation to GDP. In the following, we briefly elaborate the selected parameters in our *Innovative Power Index* (IPI):

- Number of Patents: Patents are without any doubt an excellent indicator for the innovative behavior of companies and institutions in a nation. Patent offices register

almost all innovations and protect them against the use of external parties. Thus we gathered data on patents per year and per country out of the World Intellectual Property Organization database. We give them a weight of 50 percent in our own *Innovative Power Index* (IPI).

- All other variables obtain a weight of 10 percent respectively. Business startups (time, density and costs): The innovative potential of small enterprises is also a good indicator. Especially business startups in the IT and biotechnology industry are considered to be very innovative. In addition, we include the share of high skilled people to the labor force and the expenditure per student in relation to GDP. Beyond controversy high-skilled persons have a larger potential in inventing innovations than low-skilled. Hence, we gather data for the proportion of graduates to the labor force and the related costs for the public education. Governments how investment more money for education should also have a higher potential for future innovations.

As already specified, we also include real GDP growth as a measure for the overall economic situation in our econometric model. GDP measures the overall economic development and can only partially be changed via public policy. In fact, economic growth theory argues unambiguously that economic growth is mainly created by private businesses and increasing productivity and rather not by public spending [13]. Nonetheless, economic growth does not only have relevance to Venture Capital, it similarly attracts skilled workers that reinforce innovation too.

Next, we introduce the econometric methodology. In a first step, we estimate certain specifications of a panel regression. We start with a small benchmark model and thereafter add several variables. In a second step, we check the robustness of our results by estimating a dynamic panel regression including two ARMA terms (Appendix). In general, we attempt to answer the question: Are venture capital investments related to the innovative power of a state and/or the overall economic situation? The estimated fixed effect panel model is of the following type

$$Y_{i,t} = \beta_0 + \beta_1 X_{1i,t} + \beta_2 X_{2i,t} + \ldots + \varepsilon_{i,t} \qquad (1)$$

where *Y* measures the growth of venture capital or as a proxy private business investments. The subscript *i* denotes the country and respectively *t* the year. The vector *X*

represents the *Innovative Power Index* (IPI) of a state or the explicit sub-components for country *i*, at time *t*. The error term ε is in line with all standard assumptions. The dynamic panel regression model is according to

$$Y_{i,t} = \beta_0 + \beta_1 X_{1i,t} + \beta_2 X_{2i,t} + \ldots + \beta_{n-1} Y_{i,t-1} + \beta_n \cdot Y_{i,t-2} + \varepsilon_{i,t} \qquad (2)$$

where $Y_{i,t-1}$ and $_1Y_{i,t-2}$ represent the one-period and two-period time lag respectively.

4. Empirical Results

We estimate different panel models to verify our hypothesis. The first model estimates the direct relationship between growth of Venture Capital and our IPI-Index and real GDP growth. Economically one would intuitively expect a positive relationship between VC and the innovative power index as well as GDP (Table 1). At first glance the regression analysis confirms this relationship, however, the IPI-Index is not significant.

Table 1: Benchmark Panel Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-1.036	0.425	-2.441	0.015
IPI Index	0.022	0.037	0.609	0.543
Real GDP	1.995	0.143	13.965	0.000
R-squared	0.472012	Mean dependent var		2.882699
Adjusted R-squared	0.467631	S.D. dependent var		6.744281
S.E. of regression	4.920873	Akaike info criterion		6.037068
Sum squared resid	5835.814	Schwarz criterion		6.080066
Log likelihood	-733.5223	Hannan-Quinn criter.		6.054385
F-statistic	107.725	Durbin-Watson stat		1.435399

Dependent: Growth in Venture Captial. All variables are growth rates. Source: own estimation.

The benchmark model in Table 1 attempts to explain Venture Capital growth based on exogenous factors given by the state, which is measured by the IPI-Index, and on an endogenous factor real GDP growth. Table 1 show that real GDP growth is highly significant and explains a significant proportion of VC. Consequently, for high VC investments the overall economic situation is far more important than public spending for innovations and the public infrastructure. The reason for the insignificant relationship of VC and the innovative power index (IPI-Index) is mainly attributed to a series of political

and cultural factors. According to the OECD Education report [14,15], despite a normal proportion of university graduates in technical subjects in some countries, there are several cultural and institutional reasons why high skilled workers are not utilized effectively. Moreover, in some countries such as the UK both the industrial and innovation sector is relatively small and thus the respective state innovation infrastructure is less effective. Moreover, in most of the countries the education system is financed by tuition fees and thus mitigates the pool of VC. Thirdly, the IPI-Index does not include political conditions of the business sector. For instance Germany has a high share of science graduates and no tuition fees but there is no risk-related business culture such as in the UK or US. In addition, the legal requirements of a Limited (Ltd.) in the UK are easy achievable for almost all startups. Hence, there are many factors not included in our IPI-Index. All these factors may balance out some country specific features but they explain the insignificant coefficient in our regression model. Of course, the number of patents has the greatest weight in our IPI-Index, however, a patent is only a measure of invention output. But the IPI-Index includes output und input measures determined by the public innovation power of a state.

Next, we extend the model by the new Google measure for Venture Capital (Table 2). The Google variable captures the public attention of VC via the searches of this word in Google.com [16]. It turns out that this variable strongly explains VC growth. The coefficient is positive that means the higher the attention on VC the higher the real VC volume. In addition, the coefficient is significant at 5 per cent.

Again the most significant variable is real GDP growth. This coefficient is positive and significant even below 1 per cent. Surprisingly in model 2, the coefficient of the IPI-Index is even negative and almost significant at 10 per cent.

What could be the reason for this unexpected result? Through having a short look on the VC investment figures we can observe for some countries outliers and it is generally acknowledged in literature that the dotcom bubble and the financial crisis of 2007 to 2009 caused extreme fluctuations in the data. Moreover, we have not distinguished between private equity and venture capital that may also cause this result [17,18]. In addition, we estimate the panel regression including ARMA terms. The results are reported in the

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appendix. This regression checks the robustness of our findings. Table 2B confirms and strongly supports our econometric findings.

Table 2: Panel Regression Including Google Data

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.207	0.637	-0.325	0.745
IPI Index	-0.059	0.036	-1.658	0.100
Real GDP	2.485	0.148	16.743	0.000
Google-VC	0.099	0.039	2.521	0.013
R-squared	0.684685	Mean dependent var		2.061392
Adjusted R-squared	0.677879	S.D. dependent var		7.138583
S.E. of regression	4.051552	Akaike info criterion		5.66365
Sum squared resid	2281.695	Schwarz criterion		5.746527
Log likelihood	-400.951	Hannan-Quinn criter.		5.697327
F-statistic	100.6095	Durbin-Watson stat		1.781622

Dependent: Growth in Venture Captial. All variables are growth rates. Source: own estimation.

Next, we take a closer look to the variables behind our IPI-Index and estimate a regression with the number of patents, the time for setting up a startup, cost for a startup, and again real GDP growth and Google search. Table 3 illustrates the result of this regression model. Again this regression confirms our findings in model 1 and model 2. The public infrastructure now measured explicitly by respective variables, included in the IPI-Index, do not have a significant impact on venture capital growth. Even if the coefficients of these variables are not significant, at least the sign seem to be in line with our expectation. Merely real GDP growth and Google attention have a significant impact on the growth of Venture Capital (Table 3). Moreover, Table 3B contains the same regression model, however, including ARMA terms to check the robustness. Again the general model confirms our results (Appendix – Table 3B).

According to an international study of the Experts Commission for research and innovation (EFI), Germany is considered as one of the most competitive countries in regards to its innovation power. They identify the most innovative branches as automotive, engineering and chemistry. Interestingly, despite this evidence German Venture Capital data does not confirm this clear relationship because all these branches are 'traditional' or 'old' branches, driven by large corporations. Hence, the amount of VC

investment is relatively low. Again this may explain why the IPI-Index in some regression models is not significant despite a high potential of public innovation.

Table 3: Explicit Panel Regression Including Google Data

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.373	1.042	0.358	0.721
Number of Patents	0.208	0.309	0.671	0.503
Startup per day	0.025	0.165	0.149	0.881
Cost per Startup	-0.106	0.074	-1.441	0.152
Real GDP	2.402	0.145	16.537	0.000
Google-VC	0.096	0.040	2.409	0.017
R-squared	0.684757	Mean dependent var		2.061392
Adjusted R-squared	0.673251	S.D. dependent var		7.138583
S.E. of regression	4.080553	Akaike info criterion		5.691394
Sum squared resid	2281.175	Schwarz criterion		5.815709
Log likelihood	-400.9347	Hannan-Quinn criter.		5.74191
F-statistic	59.51694	Durbin-Watson stat		1.699264

Dependent: Growth in Venture Captial. All variables are growth rates. Source: own estimation.

Overall, the econometric models confirm that the macroeconomic market dynamics is far more important for venture capital than the public infrastructure such as a high share of university graduates or low administrative hurdles for startups. Consequently, the public infrastructure may support the VC dynamics, however, neither cause nor significantly influence it. Hence, we conclude that for economic growth and innovation the market dynamics is far more important than government programs or subsides. This result demonstrates the limits of the government as a key macroeconomic player for economic growth. The best the government can do is to guarantee free markets and set the rules that markets work efficiently.

5. Conclusion

Our paper has studied the question: What is the relationship between Venture Capital (VC) investments and the innovation power of the state? The result shows that there is a weak linkage between VC and innovation on average. We argue that the weak linkage is not so surprising because the macroeconomic situation is the major driver of future expectations, confidence, and thus VC investments. The public infrastructure by a state cannot enforce but just indirectly influence innovation. Secondly, the insignificant

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coefficient has to do with several external shocks during the past years especially the dotcom bubble of 2000 and the financial and economic crisis of 2007 to 2009. No doubt, these events have biased financial data series significantly. Moreover, the data constraint is a further limitation that may answer why the results are not as expected in terms of the IPI-Index.

Still, we do think that the paper contains interesting conceptual and empirical insights. Frist, the innovative power index (IPI-index) that is to our knowledge new in literature is a good tool to be used in further empirical work in this field of research. This index has the potential to shed new light on the old question of innovation and economic growth in future. Most of the current research focuses predominantly on the number of patents. In our opinion this is far too shortsighted. Thus our IPI-index provides a more comprehensive alternative. Additionally, many patents do not automatically end up in market-ready products. Many of the registered patents are just saved as an idea but not used to develop a technology or product. This is *called defensive patenting*. Considering this issue it is obvious that there is a strong need for a broader characterization of innovation as we did with our IPI-Index. The empirical result, however, shows that even the broad IPI-Index is not significantly linked to VC. Consequently VC investments are mainly determined by the overall economic conditions and the public attention on VC, which is innovatively measured by Google search data.

Of course, there are several other factors that may explain the relationship between VC and innovation of a state. For instance soft-oriented or cultural factors, such as that some societies, for instance the US, are more brave and risk-oriented than others. In addition, there may exist an inhibition threshold to establish new ideas and that threshold is determined partly by the public environment. Despite all this, we conclude that the US is not a better innovator but it uses existing ideas more efficient and even more importantly it is better to make the ideas market-ready. European nations are innovative too but they struggle with the realization of ideas and they had economically not such a robust development than the US in the past decade. To explain this issue in future, we probably need further measures for sector or country specific network effects, such as the Silicon Valley.

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APPENDIX
Table 2B: Panel Regression Including ARMA

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.238	0.627	-0.379	0.705
IPI Index	-0.064	0.035	-1.824	0.070
Real GDP	2.421	0.145	16.720	0.000
Google-VC	0.096	0.042	2.272	0.025
ARMA-VC (-1)	0.133	0.048	2.776	0.006
ARMA-VC (-2)	-0.104	0.050	-2.084	0.039
R-squared	0.710071	Mean dependent var		2.061392
Adjusted R-squared	0.699489	S.D. dependent var		7.138583
S.E. of regression	3.913289	Akaike info criterion		5.607686
Sum squared resid	2097.995	Schwarz criterion		5.732001
Log likelihood	-394.9495	Hannan-Quinn criter.		5.658202
F-statistic	67.10581	Durbin-Watson stat		2.04695

Dependent: Growth in Venture Captial. All variables are growth rates. Regression includes ARMA terms for the depedent variable. Source: own estimation.

Table 3B: Panel Regression Including ARMA

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.352	1.012	0.348	0.729
Number of Patents	0.192	0.304	0.632	0.528
Startup per day	0.013	0.161	0.079	0.937
Cost per Startup	-0.095	0.073	-1.297	0.197
Real GDP	2.335	0.144	16.248	0.000
Google-VC	0.091	0.044	2.077	0.040
ARMA-VC (-1)	0.123	0.050	2.465	0.015
ARMA-VC (-2)	-0.104	0.051	-2.040	0.043
R-squared	0.70779	Mean dependent var		2.061392
Adjusted R-squared	0.692638	S.D. dependent var		7.138583
S.E. of regression	3.957646	Akaike info criterion		5.643494
Sum squared resid	2114.5	Schwarz criterion		5.809248
Log likelihood	-395.5098	Hannan-Quinn criter.		5.710848
F-statistic	46.71376	Durbin-Watson stat		1.951279

Dependent: Growth in Venture Captial. All variables are growth rates. Regression includes ARMA terms for the depedent variable. Source: own estimation.

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