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Full Length Article

Venture capital healthcare investments and health care sector growth: A panel data analysis of Europe

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Abstract

We examine the effect of venture capital investments on health sector growth, using a macro sample data from EVCA (now Invest Europe), World Bank, OECD and Eurostat databases covering 23 EU/EEA countries between 2000 and 2019. We follow the system GLS fixed effect and random effect approach, posit and find evidence that VC healthcare investments and age of VC industry increase healthcare sector growth in Europe. Life expectancy (one of the proxy variables for health sector growth) shows increasing trends in Europe. We also find that innovation, financial sector development, macroeconomic variables and healthcare infrastructure significantly increase health sector growth. We conjecture that VC investors may enjoy returns on investments which decipher into social returns to health sector outcomes. Our study makes justification for private-public partnership to support health sector growth. We recommend more funding support and inducement policy models tailor-made to reap benefits from overall health sector growth.

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JEL classification: H51; G24; I115

Keywords: Government health expenditures; Health sector growth; Venture capital; Venture capital healthcare investments

1. Introduction

Threats posed by diseases like Alzheimer's, Parkinson's and Ebola compel nations such as the US to make huge public investments in the health sector to conduct research, the outcome of which serves as therapy to cure the diseases (Fleming, 2015). The recent global pandemic caused by the coronavirus (Covid-19) has exposed that, in most advanced countries in Europe and other parts of the world, the healthcare industry still needs greater investment to cater for eventualities. Securing finance for early stage innovation in healthcare is very challenging (Karpa & Grginović, 2019). The private sector, through the venture capital (VC forthwith) industry, makes significant investments in the health sector to cushion the load on the government in meeting healthcare needs. The call for private sector investment in healthcare stems from arguments that there is excessive waste in public expenditure on health (Berwick & Hackbarth, 2012). Perhaps, with private sector involvement such as venture capitalists, it is envisaged that health sector investments could positively influence health outcomes. The question that begs an answer is whether VC investments in healthcare increases health sector growth in Europe. Compared to the US, the VC industry in Europe is still at the development stage, but recent trends show increasing investment activities in either amounts or numbers of VC-backed firms. The European healthcare sector is faced with challenges such as an ageing population, reduction in public spending. etc. that affect the industry, a situation which requires more investments to meet the health needs of the citizenry (BVCA Report, 2016; Kirigia et al., 2011; Schneider,

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2009). The devastation of the global pandemic (Covid-19) on severely affected advanced nations (including Europe) was incredible, thus signalling a global wake-up call to channel considerable investments to the health sector. Fleming (2015) bemoans the decline in early stage investments by VCs.

In spite of these challenges, the healthcare sector continues to have global attraction for VC activities probably due to reasons like high returns of the healthcare market, successful exits, ageing population, people living longer with chronic diseases. etc. (BVCA Report, 2016; Silicon Valley Report, 2018). Europe is experiencing steady growth in public-private partnership in healthcare infrastructure investment in the form of buildings, large technology systems, and associated health services (Barlow et al., 2013). The World Economic Forum Report (2019) reveals that VC has the potential to turn scientific discoveries into products for patients and has driven healthcare innovation especially in low and middle income countries. Despite the increasing presence of VC investment in healthcare, to date empirical evidence on its impact on the sector's growth within the context of Europe is scarce. This study advances knowledge of the private sector involvement in the health sector through VC investments. Specifically, the paper explores VC investments in Europe, analyses whether VC investments in healthcare and age of the VC industry increase health sector growth. The study also looks at how innovation, financial sector development, macroeconomic factors and healthcare infrastructure affect health sector growth.

One paper motivating this study is 'Eliminating Wastes in US Healthcare' by Berwick and Hackbarth (2012). The authors argue that failures of care delivery, care coordination, overtreatment, fraud and abuse, etc., contribute to huge waste in public expenditure on health which, in turn, negatively affect health outcomes. We deviate from Berwick and Hackbarth (2012) by focusing on the private sector (VC) using Europe-based data to determine the relationship between healthcare investment and health sector growth. Another motivation emanates from Karpa and Grginović (2019) who investigate long-term investment into early stage life sciences projects for healthcare in Europe. The authors focus on the motivations and strategies for VC investments in early stage and report volatile financing environment in Europe. Karpa and Grginović (2019) conclude that long-term returns outperform other sectors and that scepticism of the VC to invest in the health sector remains a puzzle. We align with Karpa and Grginović (2019) and extend the argument to how VC investments in healthcare affect the growth of the health sector. The authors adopt a micro approach by looking at the returns, strategies and motivations for VC firms, but the current paper uses a macro approach which considers the relation with a broad health sector (country level) and the economy as a whole. Our study projects the European VC industry to attract investments leading to a vibrant market that still trails its US counterpart. Another source of motivation comes from the work of Lehoux et al. (2016) whose theoretical paper from Canada focuses on the mandate of VCs on how they operate, and policy support for medical innovation. Apart from the paper being theoretical and lacking data from Europe, it does not touch on the relation between healthcare investments and health sector growth. We employ a quantitative methodological approach to address the gaps identified.

We use panel data on VC investment activities from EVCA, now Invest Europe, and healthcare data from EUROSTAT, OECD, WHO and World Bank websites. The study contributes to research in the following ways: first, with support from Europe-based data, we provide evidence that VC investment in healthcare increases health sector growth by increasing fertility rate and life expectancy and reduces death rate. Thus, private sector investment in healthcare removes the scepticism surrounding public expenditure on health outcomes. Second, the study contributes to knowledge by confirming that the age of the VC industry increases health sector growth. Our finding craves support for advancing policy to deepen the European VC industry which still trails the US. Third, using Europe-wide cross-sectional data it enables generalisation of the findings. This provides a wider perspective of the subject as compared to single country-based studies. The study reveals that innovation, financial sector development, macroeconomic factors and healthcare infrastructure increase health sector growth. Finally, we proffer evidence that it is not enough to commit resources into healthcare, but it has to be monitored and complemented with other factors to ensure social return on investment. Therefore, we suggest public-private partnerships in healthcare investments as well as well coordinated and sustained policies and programmes aimed at promoting healthy lifestyles in Europe. Investors may enjoy financial returns on their investment, which should, however, be aligned with the benefits to society (social return). Thus regional bodies such as the EU and EEA can rely on our findings to design policy interventions to ensure equity in supporting the growth and development of the VC industry.

The rest of this study is organised as follows: Section two is dedicated to theoretical development and review of literature. Section three describes the data and methodology for the study. Section four covers the empirical results and discussions and section five concludes with the implications.

2. Related literature and hypothesis

2.1. The venture capital industry in Europe

Invest Europe (formerly EVCA) defines venture capital as an "investment in unquoted companies by specialized VC firms." It is a subset of private equity, that is, equity investment in companies not listed on a stock market, as opposed to publicly traded companies. The VC industry in Europe started operations in the early 1980s with the establishment of VC firms. This was followed by the setting up of professional associations like the European Private Equity and Venture Capital Association (EVCA), now Invest Europe, and the British Venture Capital Association (BVCA) in 1983 (Kaur, 2007). The VC market in Europe, according to Manigart (1994), began in the UK and Ireland, followed by continental Europe with active participation by domestic banks. The

European VC market is modelled after the US, but differs in their institutional environment, tax and securities laws regarding VC investments (Manigart, 1994).

Until recently, the US VC market was deemed to be the only active market but Europe, Asia and the rest of the world and experiencing some growth in their operations. The strength of the US VC industry lies in its existence and years of operation among other factors. In the opinion of Fleming (2015), regulatory support and reimbursement policies aimed at driving and funding early stage innovation research could help the VC industry. The US VC market enjoys government support by establishing models to serve as catalysts for innovative investments into healthcare (Perla et al., 2018). In Europe, governments support fundraising activities to enhance liquidity in the VC industry. Despite this effort, Europe still trails the United States in size, age and depth of the VC markets.

The European VC market has grown significantly for the past two decades, from a fundraising of around €48 billion and investment level of €35 billion in the year 2000 to a peak of €97.3 billion in fundraising and €80.6 billion in investment in the year 2017 (Invest Europe Report, 2018). The experience of the venture capitalists may prove decisive in most venture capital deals (Wang et al., 2003). An experienced venture capitalist may have witnessed many venture scenarios which inform reasonable recommendations to spur the growth in portfolio firms. VC firms that have been in the industry for a long time have enviable reputations and, therefore, their advice and judgements are regarded by entrepreneurs. Empirical studies support the fact that how long a VC firm has been in operation to a large extent impacts the growth of its portfolio firms. This is in line with Barry et al. (1990) who report that the presence of experienced venture capitalists on the board of a portfolio firm lowers IPO underpricing. Experienced VC firms have a broader knowledge base to draw from and are, therefore, better positioned to add value to their investee firms. However, what is unknown is the effect of the age of the VC industry on the growth of the health sector. Seeing that the age and experience of the venture capitalist appear to be good indicators for impacting healthcare growth, the study hypothesises that:

H1. *A long existing VC industry increases health sector growth*

2.2. VC investment in the health sector in Europe

The manifold problems confronting the European healthcare sector, such as ageing population and reduction in public expenditure, call for capital investments into the sector, hence the involvement of VCs (Rossi et al., 2012). Research indicates that innovative health firms contribute to the improvement of healthcare delivery (Robinson, 2015). The healthcare sector has witnessed considerable change with respect to VC investments in the last two decades (Health Affairs Report, 2019). The continuous improvement of healthcare is ideal, as overall wellbeing of a citizenry in contributing to 'economic growth largely depends on the sector (Cervellati and Sunde, 2011; Weil, 2007).

Some health-related firms that receive VC funding are not limited to digital health products, innovative wearable devices, mobile health applications, telemedicine, personalised medicinal tool manufacturers and suppliers within the healthcare sector, but service providers as well (Pitchbook VC Report 2018). Future VC investment opportunities are tilting towards medical technology, pharmaceutical, service providers and IT health infrastructure firms (BVCA Report, 2016). Despite the reported interest of VCs' support to startups, especially in the health sector, studies confirm that less than one per cent of startups in all sectors get funded by venture capitalists and the majority get funded by personal loans, credit, and family and friends (Thillai Rajan, 2010). The KPMG Report (2018) indicates signs of renewed increase in investments in recent times. For example, the last two decades (apart from the crisis period) witnessed improved VC investments across all sectors, especially in the healthcare sector. For instance, between 2010 and 2017, the value of VC investments in digital health alone increased by 858 percent, with more than $41.5 billion investments made in a decade (Health Affairs Report, 2019).

In the year 2000, healthcare related firms in Europe accounted for 11.8% of the companies financed by VCs representing 10.8% of total investments (EVCA Report, 2001). The pharmaceuticals, medical technology and healthcare services constitute the main sub-sectors attracting VC investments. The healthcare service subsector is regarded as the strongest area of growth in Europe (Pitchbook Report, 2018). Startups in digital healthcare venture investments alone increased from $1.1billion in 2011 to $11.5 billion in 2017 to an all-time record of $14.6 billion in 2018, more than 14 times the investment recorded in 2010 (StartUp Health Insight Report, 2018). Again, between 2010 and 2018, the value of startup digital healthcare venture investments grew more than 917% (Health Affairs Report, 2019) far exceeding the growth in overall VC investments in all sectors. In comparative terms, while the overall Europe VC investments in the ICT sector has reduced significantly from 44.2% in 2000 to 19.3% in 2017, that of the life sciences and health sector has increased from 5.8% in 2000 to 11.5% in 2017 (Invest Europe activity Invest Europe Report, 2017). Recent reports of VC investments in the pharmaceutical and medical technology sectors in Europe indicate a growth trajectory from $1.9 billion and $1.4 billion in 2017 to $3.5 billion and $3.1 billion in 2019 (Silicon Valley Bank Report, 2020). Moreover, angel investors also offer investments to healthcare related firms, especially startups, thus helping them to turn their dreams and ideas into viable commercial ventures.

Empirical evidence suggests that the VC industry (rather than non-VC industry) impacts economic growth through financing innovative ventures (Kolmakov & Shalaev, 2015). In a study of the impact of VC investments on economic growth and innovation in the US and Russia, the authors underscore the fact that the VC market's contribution to R&D spending or

gross investment is low. Kolmakov and Shalaev (2015) admit the contradiction in the impact of VC investment on modernisation between theory and practice, they reiterate the importance and significance of VC investments albeit the delay. What is yet to be known is the impact of VC healthcare investments on health sector growth within Europe. Studies from the Eurozone area show long run relation between VC investments, financial development and economic growth (Pradhan et al., 2017a). The European Union made significant investments in the health sector between 2014 and 2020. A report by the European Structural and Investment Fund indicates that €3.96 billion have been invested in health infrastructure, followed by €3.71 billion in access to healthcare services and €979 million in ICT solutions and e-Health (ESIF, 2020).

Trends in overall VC investments year after year in Europe suggest improvement in investment, thus impacting the overall economy (Invest Europe Report, 2018). There is a paucity of research pointing to the evidence of the effect of VC investment in explaining healthcare growth in Europe. It is not enough for investors to receive their return on investment, but there should be positive impact of VC investments on health outcomes. Berwick and Hackbarth (2012) bemoan the waste in the US healthcare expenditure, which suggests a negative impact on health outcomes. Thus, in a health system where monitoring is weak, investments in the health sector may be counter-productive. Therefore, the sector provides an ideal context to examine VC investments directed at the healthcare sector and explores the effect of the investment. There is a paucity of research to resolve whether investments in the health sector produce positive or negative outcomes. We conjecture that VC investments significantly affect the healthcare sector growth in Europe and, therefore, hypothesise that:

H2. *VC investment activities significantly affect health sector growth.*

3. Methodology and data

3.1. Data and materials

We employ an unbalanced panel of 23[1] EU/EEA member countries for the period 2000–2019. The choice of sample countries is purely governed by the fact that they are members of EU/EEA countries and also data for variables used for the study were available and could be accessed for such countries. The healthcare related indicators and macroeconomic data were obtained from the official websites of https://ec.europa.eu/eurostat/data/database, https://datacatalog.worldbank.org/and https://stats.oecd.org/Index.aspx?DataSetCode=SHA whereas venture capital investment activities data were from European Venture Capital Association (EVCA) now Invest Europe (the umbrella body of national private equity and venture capital associations in Europe).

The venture capital is represented by total investments or allocation of VC funds to the health sector of a country expressed in natural logarithmic terms and the number of years VC has been operating in the country in our model. We adjust for VC funds as a percentage of GDP and per-capita expenditure on health. We also include variables on innovation, financial sector development, macroeconomic factors and healthcare infrastructure. The choice of control variables is informed by growth and economic theories in which these variables, along with measures of human capital are found to impact healthcare growth (Pereira et al., 2019). The data span from 2000 to 2019, providing a maximum of 20 observations per country for each variable. The choice of the long period study is expected to provide robust evidence of the effect of VC investment activities on the healthcare sector growth.

Life expectancy at birth is used as one of the proxy variables for healthcare sector growth. This proxy variable may come with some challenges because a country may have high life expectancy, but the majority of its population might be suffering from illness and might not be productive, thus not contributing to the growth of the country (Bhargava et al., 2001). For this reason, we include other variables such as fertility rate and death rate. In spite of this argument and health being a multi-dimensional concept, we follow previous research because these variables have been among the widely used indicators to gauge the growth of the health sector of a country (Acemoglu & Johnson, 2007; Bloom et al., 2004; Cervellati & Sunde, 2011).

3.2. Econometric model

In the empirical estimation of the effect of VC investment on healthcare sector growth, we measure healthcare sector growth (dependent variable) by three variables namely life expectancy, fertility rate and death rate of a country (see Table 1 for variable definitions). We employ two main estimation techniques in a graduated manner to address biases. We initially use a baseline OLS estimation technique. In order to address cross-country heterogeneity, we run fixed and random effect models. We employ the Hausman test to select which of the two models is appropriate. Even though sample size is above the minimum, we resort to this estimation technique because of the relatively small size of the observations. We state, therefore, our basic model of the healthcare sector growth as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \gamma_j Z_{it} + \xi_{it} \quad (1)$$

where Y_{it} represents the healthcare sector growth, X_{it} and Z_{it} represent the vector of the explanatory and control variables, respectively, while β *and* γ are coefficients of parameters to be estimated and ξ_{it} is the error term, the observational

[1] The list of countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom.

Table 1
Variable definitions.

Variables	Definition/Measurement	Data Source
Dependent Variable		
Health sector growth measured by three variables:	Number of children that would be born to a woman if she were to live to the end of her childbearing years.	**World Bank, OECD and Eurostat**
Fertility rate		
Life expectancy in years	Life expectancy is defined as the number of years a newborn is expected to live.	
Death rate	Number of deaths occurring during the year, per 1000 population.	
Independent Variables		
VC allocation to healthcare	VC investments directed to healthcare-related firms	**EVCA now Invest Europe**
Age of VC industry	Number of years VC has been in operation in the country	**EVCA now Invest Europe**
Control Variables		
VC industry and macroeconomic factors		
VC fund as percentage of GDP	Percentage of VC investment in relation to GDP.	**EVCA now Invest Europe**
Per capita expenditure on health	Current expenditures on health per capita in current Euros	**World Bank, OECD and Eurostat**
Innovation		
Business sector R&D expenditure	R&D expenditures include all expenditures for R&D performed within the business enterprise sector during a given period.	
Percentage of GDP on R&D	Gross domestic expenditures on research and development (R&D), expressed as a percentage of GDP.	
Infrastructure		
Number of hospital beds per 1000	The number of hospital beds per 1000 residents of the country.	
Financial sector development		
Financial development (bank ROE)	Level of current health expenditure expressed as a percentage of GDP commercial banks' pre-tax income to yearly averaged equity	**World Bank, OECD and Eurostat**

Notes: All of the data are annual over the period 2000–2019

units are i and t indexes time. We take into account the individual specific effects α_i and rewrite our model as follows:

$$Y_{it} = \alpha_1 + \beta_1 X_{it} + \gamma_j Z_{it} + \mu_{it} + \xi_{it} \quad (2)$$

Fixed effect model account for composite error vit = $\alpha_1 + \xi_{it}$

At this stage, we extend the model to take into account the possibility that the intercept may change across individuals and time, which results in:

$$Y_{it} = a_i + y_t + \beta_1 X_{it} + \gamma_j Z_{it} + \xi_{i,t} \quad (3)$$

We assume that other investments may affect healthcare sector growth and, therefore, we adjust for VC fund as a percentage of GDP and per-capita expenditure on health in our model. We follow Pradhan et al. (2020) to include variables on innovation, healthcare infrastructure and financial sector development as control variables which affect the VC industry. We perform Hausman specification test to check whether there is a correlation between the unique errors and the regressors. The criterion is such that, if the heterogeneity between cross sections and over time is attributable to a random process which does not correlate with the regressors, the random effect model is preferred.

Since our dependent variable is health sector growth, the equation for the model is:

$$HSGrowth_{i,t} = \sum_{j=1}^{n} \beta_j IndpVar_{i,t} + \sum_{j=1}^{n} \gamma_j ControlVar_{i,t} + \varepsilon_{i,t} \quad (4)$$

where. HSGrowth=health sector growth measured by fertility rate, life expectancy and death rate

β and γ= parameters to be estimated for the set independent and control variables, respectively,

i,t=country and time measures for panel data

εi,t=individual fixed effect and error term

HSGrowth *(dependent variable) is measured by fertility rate, life expectancy in years and death rate*

IndpVar represents independent variables comprising VC allocation to healthcare and age of the VC industry.

ControlVar represents control variables categorised under VC industry and country variables, innovation, infrastructure and financial sector development. From prior research (such as Pradhan et al., 2017a; 2018; Pradhan, et al., 2017b) the inclusion of these variables in their models shows significant

effect on the VC industry in the sampled areas. VC industry and country variables are represented by VC fund as percentage of GDP and per capita expenditure on health; innovation is measured by log of business sector R&D expenditure and percentage of GDP on R&D expenditure while financial development is measured by bank return on equity (ROE).

The equations that contain all the variables can be seen as:

$$HSGrowth_{i,t} = \alpha_1 + \beta_1 LnVC\ Alloc\ to\ Hlthcare_{i,t} + \beta_2 Age\ of\ VC\ ind_{i,t} + \gamma_1 VC\ fund\ as\ \%\ of\ GDP_{i,t} + \gamma_2 LnPer\ cap\ hlth\ exp_{i,t} + \gamma_3 LnBus\ sect\ R\&D\ exp_{i,t} + \gamma_4 Perc\ GDP\ on\ R\&D_{i,t} + \gamma_5 No\ of\ hosp\ beds\ per\ 1000_{i,t} + \gamma_6 Fin\ dev_{i,t} + \varepsilon_{i,t} \quad (5)$$

4. Results and analysis

4.1. Results

This section reports the descriptive statistics, correlation matrix of venture capital investments in health and health sector growth in Europe. Table 2 shows the summary statistics for the variables.

Table 2
Descriptive statistics.

Summary Statistics					
Variables	N	Mean	St. Dev	min	max
Life expectancy	460	79.084	2.962	71	83.8
Fertility rate	460	1.566	.239	.2	2.1
Death rate	460	10.032	4.781	6.1	105
No. of hospital beds per 1000	437	5.351	1.754	2.14	9.12
VC fund as % of GDP	458	.13	.222	0	2.138
Lnper-capita expenditure on health	418	7.521	.953	4.164	9.048
Age of VC industry	460	20.235	9.158	0	46
LnVC allocation to healthcare	460	9.568	4.287	0	15.107
Lnbusiness sector R&D expenditure	438	7.742	1.761	2.679	11.233
Percentage of GDP on R&D	439	1.657	.908	.15	3.87
Financial development (bank ROE)	414	14.734	14.748	−13.85	198.94

Table 2 shows the descriptive statistics for the variables used in the models. All the dependent and independent variables had 460 observations. For the control variables, apart from the financial development and per capita expenditure on health which have the least observations of 414 and 418, respectively, all the other variables had close to 440 observations each. The average age of the European VC industry is 20 years with life expectancy (absolute value) of 79 years. Apart from the age of the VC industry (SD = 9.15) and financial development (SD = 14.748) all the variables indicate consistency and less variability with standard deviations less than 5. The nature of the data set can be said to be homogenous and normally distributed.

Fig. 1 shows a panel data time series graph for health sector growth which is measured by fertility rate, life expectancy and death rate for the sampled 23 European countries. The trend shows relatively favourable life expectancy, which is above 70 years. Almost every country is recording progressive life expectancy throughout the period under study. Among the implications of high life expectancy is the need to support an ageing population who become dependent on the actively working population. Death rate is higher than the fertility among the countries with the former showing an average of 10%. On the whole, the figures for health sector growth are encouraging and VC investment in this sector will massively improve upon healthcare in Europe.

4.2. Empirical results and analysis

This section reports the baseline OLS regression followed by the fixed and random effect regressions. In order to ascertain whether VC investments affect health sector growth, we estimate the first model using an OLS for the group of 23 countries with the control variables. The OLS result from Table 5 shows that VC allocation to healthcare and age of the VC industry significantly increase health sector growth when fertility rate and life expectancy are used as dependent variables, respectively. The variables for innovation (business sector R&D expenditure and percentage of GDP expenditure on R&D) show significant effect on health sector growth. However, what is surprising is the percentage of GDP on R&D's negative relation with life expectancy and positive relation to death rate. These are very contrasting expectations because the authors expected otherwise.

Apart from business sector expenditure on R&D, which shows significant negative relation with fertility rate, VC allocation to healthcare, per-capita expenditure on health, percentage of GDP on R&D and financial development (bank ROE) significantly increase fertility rate. From Table 5, it can also be seen that the age of the VC industry, per-capita expenditure on health and business sector expenditure on R&D significantly increase life expectancy. However, VC allocation to healthcare, number of hospital beds per 1000 and percentage of GDP on R&D significantly reduces life

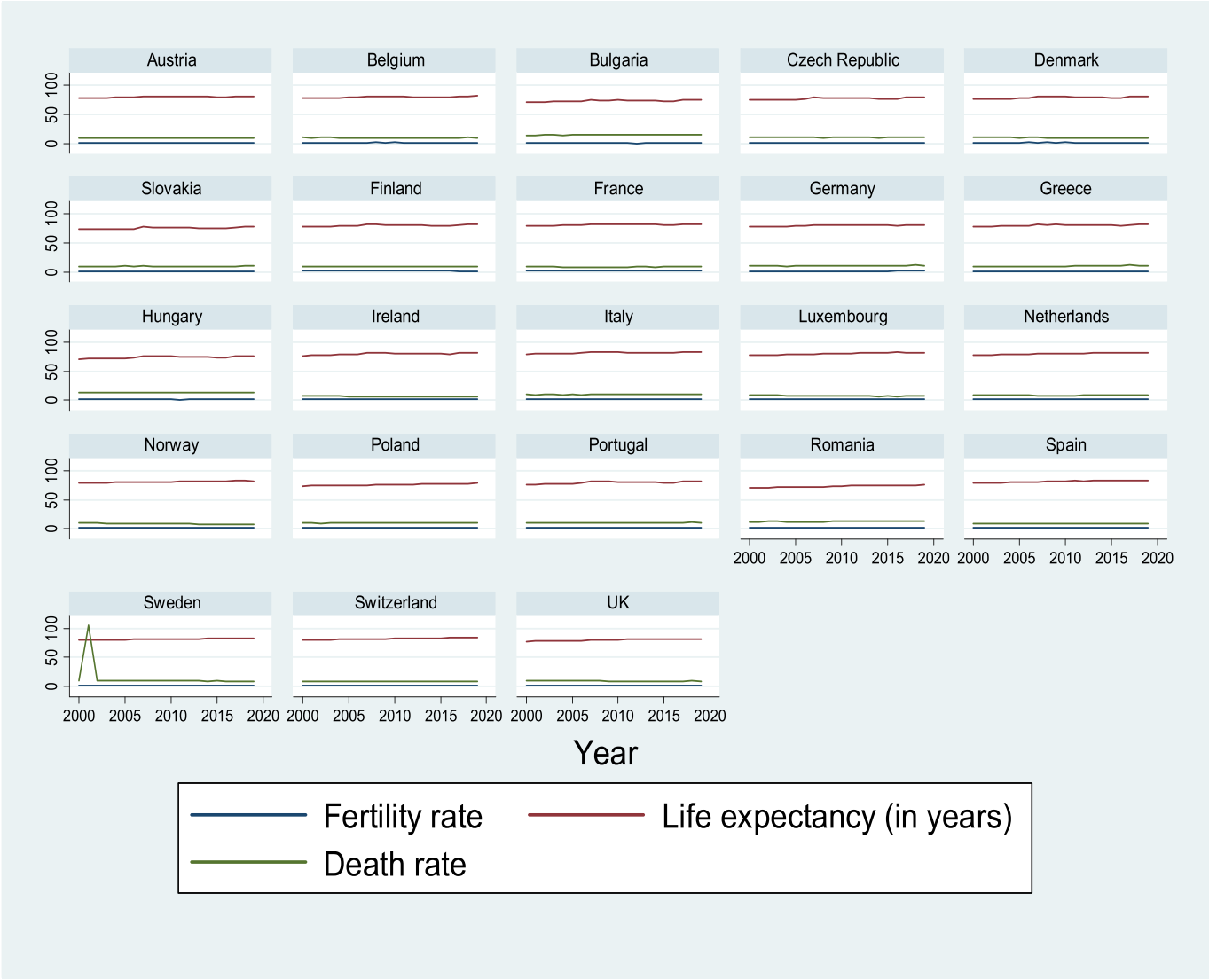


Fig. 1. Life expectancy for sampled countries.

expectancy. When death rate is used as the dependent variable, per-capita expenditure on health, business sector expenditure on R&D and financial development significantly reduce death rate. On the contrary, number of hospital beds per 1000 and percentage of GDP on R&D significantly increase death rate.

Usually, there are problems with using OLS models in panel data regressions because of the assumption that all the observations in the data set are conditionally independent. This assumption may bring about biases and misleading standard errors. The study addresses country heterogeneity using fixed effect and random effect models that encompass individual and time-specific effects. Based on the assumption that individual country error term correlates with the predictor variables, we consider the use of fixed and random effects model to cater for time-variant and invariant omitted variables. The OLS result reports no difference in intercept and slopes across countries and time period. Although this model fits the data well, one may wonder if each country or year has a different health sector growth. That is, each country may have its own health sector growth, its Y-intercept, that is significantly different from those of other countries. One could also assume that error terms vary across countries and/or year. Fixed and random effect models enable the estimation of the net effect of the predictor variables on the outcome variable.

The Hausman specification test selects the use of random effect model when fertility rate is used as dependent variable. The results from the random effect model in Table 6 show that VC allocation to healthcare significantly increases fertility rate. Other variables which significantly increase health sector growth are innovation and per capita expenditure on health. What is interesting about the result is that all the significant variables in the random effect model are also significant in the fixed effect model with differences in only the coefficients. The overall explanatory power of the model is 22.7% which means that almost 23% of variations in health sector growth is attributable to VC investments in healthcare, per capita expenditure on health and innovation. In random effect

Table 3
Pairwise correlations.

Variables	Life expectancy	Death rate	Fertility rate	No of hos- pital beds per 1000	VC fund as % of GDP	Lnper capita exp on health	Age of VC industry	LnVC allocate. to healthcare	Lnbus sect R&D expend.	Percentage of GDP on R&D	Financial dev (bank ROE)
Life expectancy	1.000										
Death rate	−0.242***	1.000									
Fertility rate	0.346***	−0.135***	1.000								
No hos beds 1000	−0.516***	0.086*	−0.277***	1.000							
VC fund as % of GDP	0.350***	−0.111**	0.272***	−0.308***	1.000						
Lnper cap exp on hlth	0.865***	−0.242***	0.552***	−0.393***	0.358***	1.000					
Age of VC industry	0.715***	−0.095**	0.406***	−0.562***	0.362***	0.613***	1.000				
LnVC alloc to hlthcare	0.562***	−0.111**	0.395***	−0.311***	0.292***	0.578***	0.609***	1.000			
Lnbus sect R&D exp	0.712***	−0.123**	0.414***	−0.225***	0.302***	0.731***	0.728***	0.768***	1.000		
Perc of GDP on R&D	0.566***	−0.358***	0.466***	−0.106**	0.237***	0.720***	0.566***	0.545***	0.714***	1.000	
Fin. Dev (bank ROE)	−0.208***	0.073	−0.017	0.041	−0.183***	−0.220***	−0.177***	−0.202***	−0.218***	−0.130***	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3 shows the correlation matrix for the variables. The correlation coefficients show low figures among most of the explanatory variables. This minimizes the problem of possible multicollinearity. Variables which show high correlation coefficients are per-capita expenditure on health against innovation variables (log of business sector R&D expenditure and percentage of GDP on R&D.

Table 4
Variance Inflation Factor and Tolerance (Test of multicollinearity).

	VIF	Tolerance (1/VIF)
LnBusiness sector R&D expenditure	5.235	.191
Age of VC industry	3.717	.269
LnPer-capita expenditure on health	3.377	.296
Percentage of GDP on R&D	2.921	.342
LnVC allocation to healthcare	2.63	.38
No of hospital beds per 1000	2.211	.452
VC fund as percentage of GDP	1.317	.759
Financial dev (bank ROE)	1.091	.917
Mean VIF	2.812	.

Table 4 shows variance inflation factor (VIF) and tolerance to check multicollinearity. The result shows that there is no multicollinearity among the explanatory variables. The explanatory variables have a mean VIF of 2.812.

models, the assumption is that all the variables are random and the results can be generalisable beyond the sampled countries.

When life expectancy is used as proxy for health sector growth, the Hausman test recommends the use of the fixed effect model. The result from models 3 and 4 in Table 6 shows that the age of the VC industry, per capita expenditure on health and VC fund as percentage of GDP significantly increase life expectancy and, for that matter, health sector growth at 99% confidence interval. The overall regression coefficient for the model is 66.4%. This is in line with the study by Lago-Peñas et al. (2013) confirming the relationship between GDP and healthcare expenditure.

On the use of death rate as a measure of health sector, the test confirms the fixed effect model because the probability value is less than 0.05, hence the rejection of the null hypothesis. The fixed effect model reports that VC fund as percentage of GDP and financial sector development significantly reduces death rate. It is also seen that VC allocation to healthcare decreases death rate, but not significantly. However, innovation and infrastructure development significantly increase death rate. On the whole, the model explains 18.2% of variations in health sector growth. Even though almost all the variables in the model show significant effect on death rate apart from VC allocation to healthcare, the Hausman test rejects the random effect for the fixed effect model.

The first hypothesis tests whether the age of the VC industry helps increase health sector growth. The result from the fixed effect model when life expectancy is used as dependent variable sustains the hypothesis that long existing VC industry increases health sector growth. A percentage increase in health sector growth is associated with a 9.7% increase in the age of the VC industry. This result is not unexpected because such long-existing markets have prevailing structures and relations for growth and development. The coefficient associated with number of years the VC industry has been in operation (age of VC industry) is also statistically significant at 1%. This is in line with Qiong et al. (2018) who report that the age and experience of the VC affect the performance.

For the second hypothesis, the result reports that VC investment in health increases health sector growth. The coefficient for the main variable of interest, VC investment allocation to health, has a positive coefficient and is

Table 5
Baseline OLS regression.

Variables	(1) Fertility rate	(2) Life expectancy	(3) Death rate
LnVC allocation to healthcare	0.0143***	−0.0811***	0.000659
	(0.00374)	(0.0240)	(0.0235)
Age of VC industry	0.00396	0.0579***	0.0237
	(0.00218)	(0.0140)	(0.0137)
LnPer-capita expenditure on health	0.128***	2.130***	−1.505***
	(0.0191)	(0.123)	(0.120)
VC fund as percentage of GDP	0.0663	0.397	0.0122
	(0.0488)	(0.313)	(0.307)
LnBusiness sector R&D expenditure	−0.0466***	0.432***	−0.0627
	(0.0128)	(0.0821)	(0.0805)
No of hospital beds per 1000	0.00457	−0.207***	0.150**
	(0.00836)	(0.0537)	(0.0526)
Percentage of GDP on R&D	0.0435*	−0.501***	0.337**
	(0.0188)	(0.121)	(0.118)
Financial development (bank ROE)	0.00195**	0.000171	−0.0140**
	(0.000689)	(0.00443)	(0.00434)
_cons	0.625***	61.07***	19.99***
	(0.141)	(0.904)	(0.885)
N	387	387	387
R^2	0.398	0.826	0.531

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5 shows the baseline OLS model for the three dependent variables. Apart from life expectancy, VC allocation to healthcare shows positive relation with health sector growth. Per capita expenditure on health significantly increases fertility rate and life expectancy and reduces death rate. VC fund as percentage of GDP is the only variable that does not show any significant relation with any of the variables in the OLS model.

Table 6
(Fixed effects and Random effects model).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Health sector Growth		**Health sector Growth**		**Health sector Growth**	
	Fertility rate	Fertility rate	Life expectancy	Life expectancy	Death rate	Death rate
	Fixed effect	*Random effect*	*Fixed effect*	*Random effect*	*Fixed effect*	*Random effect*
LnVC allocation to Healthcare	0.00493*	0.00522*	0.00468	−0.00112	−0.00512	−0.00489
	(0.00224)	(0.00227)	(0.0173)	(0.0175)	(0.00826)	(0.00848)
Age of VC industry	−0.00501	−0.00345	0.0966***	0.0791***	0.0116	0.0219*
	(0.00255)	(0.00226)	(0.0197)	(0.0165)	(0.00940)	(0.00924)
Lnper-capita expn on health	0.232***	0.195***	1.449***	1.536***	−0.178	−0.230*
	(0.0292)	(0.0254)	(0.225)	(0.184)	(0.107)	(0.105)
VC fund as % of GDP	0.00799	−0.000694	1.199***	1.197***	−0.536***	−0.565***
	(0.0315)	(0.0315)	(0.244)	(0.241)	(0.116)	(0.119)
Lnbusiness sector R&D exp	−0.0643*	−0.0443*	−0.0972	0.0746	0.320***	0.251**
	(0.0250)	(0.0206)	(0.193)	(0.145)	(0.0920)	(0.0889)
No of hospital beds per 1000	0.0246	0.0174	−0.0538	−0.134	0.186***	0.211***
	(0.0128)	(0.0115)	(0.0987)	(0.0839)	(0.0470)	(0.0468)
Percentage of GDP on R&D	0.110**	0.0707*	0.344	0.188	−0.230	−0.303*
	(0.0339)	(0.0281)	(0.262)	(0.200)	(0.125)	(0.121)
Financial Dev (bank ROE)	0.000175	0.000216	0.00201	0.00202	−0.00294*	−0.00304*
	(0.000384)	(0.000390)	(0.00297)	(0.00300)	(0.00142)	(0.00145)
_cons	0.0616	0.242	66.34***	65.48***	8.044***	8.704***
	(0.178)	(0.163)	(1.373)	(1.189)	(0.654)	(0.699)
Hausman:Chi^2 (Prob)	*9.7 (0.2846)*		*17.99 (0.0213)*		*25.61 (0.0012)*	
N	387	387	387	387	387	387
R^2	0.227		0.664		0.182	

Standard errors in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The result from Table 6 above shows the fixed and random effects models for the three dependent variables (fertility rate, life expectancy, death rate). After performing Hausman specification test, the result confirms the use of random effect model when fertility rate is used as dependent variable [see Hausman Chi^2 (probability) = 9.7(0.2846)]. This model fails to reject the null hypothesis that the difference in coefficients is not systematic. For the second and third models which use life expectancy and death rate as dependent variables, the Hausman specification test confirm the use of the fixed effect model [see Hausman Chi^2 (probability) = 17.99(0.0213) and 25.61 (0.0012) respectively].

statistically significant at 10% when life fertility rate is used as dependent variable, but not statistically significant when life expectancy is used. In the case of the third model (death rate as dependent variable) VC allocation to health sector growth significantly reduces death rate. Thus, a 1% change in VC investments in healthcare increase fertility rate and life expectancy but reduces death rate and, for that matter, health sector growth. This is in line with Pradhan et al. (2020) who report that, in the long run, venture capital investments significantly impact economic growth. Our study finds a positive relation between VC allocation to healthcare and life expectancy, but not significantly. The result corroborates the work of van den Heuvel and Olaroiu (2017) whose study finds that the relationship between healthcare expenditures and health outcomes, such as life expectancy and mortality, is complex, hence the effect of healthcare expenditures on health outcomes such as life expectancy is not clear, as a causal link between the two is not proven. They again report that, since the relationship between healthcare expenditures and health outcomes such as life expectancy is not clear, the effect of increase or decrease in healthcare expenses on health outcomes may be overestimated or underestimated. Their study further suggests that healthcare expenditures are not the main determinant of life expectancy at birth, but social protection expenditures. However, this finding runs contrary to Reeves et al. (2013), that expenditure on health may have short-term effect that may make recovery more likely, thus increasing the life expectancy of people.

5. Discussion

VC investments in healthcare show increasing trend in recent times. This is not peculiar to Europe, but also in the US where the VC industry has witnessed a paradigm shift from traditional VC to corporate VCs making huge investments in life sciences, especially for start-ups in the biotech, as reported by Simeon-Dubach (2013). Relating our paper to those of Pradhan et al. (2017b), even though they focus on economic growth whilst we pay attention to health sector growth, Pradhan et al. (2018) confirm the impact of VC investments, innovation and financial development on economic growth in Europe. It is reported that VC investments in healthcare grew by more than 50% over the 2017 figure, according to the Silicon Valley Bank report, (2018) in Europe. Perhaps such strides in investments could be said to induce health sector growth. The interest and enormous appetite for healthcare venture investments, especially among generalists and crossover investors, owing to remarkable science and technology advancements lead to more effective treatments. It is interesting to note that the stand-alone effort of VC investments in healthcare is not enough to induce the kind of desired growth, but the complement of other variables such as the age of the industry, innovation, health infrastructure, macroeconomic factors and financial development. Despite this encouraging trend in investments, there is still found a case of reduced health sector growth in Europe. There have been innovative-driven health sector investments expected to impact positively on the health sector and the economy at large and this is what the study has confirmed.

To maintain sustainable health sector growth it suggests that efforts be made to maintain and promote healthy lifestyle and social protection expenditures as a way of correcting any negative trend in European health sector growth (van den Heuvel & Olaroiu, 2017). The negative trend includes to cut down waste in public-private expenditure in the health sector (Reeves et al., 2013). In the event of perceived waste in health expenditure, the relationship between investments and healthcare outcomes can only be negative.

In a similar study, Zaman et al. (2017) find no association between life expectancy and total health expenditure. It is, however, refreshing to report from our study that, apart from VC allocation to healthcare, the age of the VC industry significantly increases health sector growth. Even though the European VC industry is not as vibrant as that of the US, there is evidence of seeing a vivacious industry in the near future. In developed VC markets, such as the US, there are deliberate models established by the government available for VCs to leverage in pushing the triple agenda of better health, better care and lower cost (Perla et al., 2018). These models serve as catalysts to spur innovation and health-based investments. VCs are private individuals or corporate investors whose economic activities (investments) are expected to increase health sector growth, such as increasing life expectancy and reducing death rate. Health sector growth has implications for the labour market and productivity as well as the overall GDP. Government expenditure on health (per capita expenditure on health) contributes to health sector growth.

When we adjust our model by VC fund as a percentage of GDP, per-capita expenditure on health, healthcare cost as a percentage of GDP, it presents the expected effect. This measurement tries to consider government healthcare expenditure which contributes to health sector growth. We find the need to control for these variables in order to truly ascertain the contribution of VC investments and age of the VC industry. It is expected that, as VC investments in healthcare increases, it will lessen government's burden on health sector commitments. The adjustment of the variables by GDP suggests that the growth of the health sector of a country has a relation with the health of its economy. This is in line with economic theory suggesting that a healthy economy affects all other sectors within it. It is also in support of the OECD Observer (2004) report indicating that healthcare performance is strongly dependent on the economy.

The relationship between innovation, financial development and healthcare infrastructure on health sector growth was reported in this study. This is in consonance with Pradhan et al. (2020) whose study in Europe confirms this relation, but for economic growth. Healthcare infrastructure such as number of hospital beds per 1000 shows government commitment to healthcare to increase access. Developing nations have suffered for lack of infrastructure in the health sector. However, even in advanced nations in Europe, the Covid-19 pandemic exposed most countries' unpreparedness for eventualities. In a well-developed financial sector, there are incentives for

investments and VC activities. These developments create enabling environments for business angels, corporate and individual VC investors to enter into the health sector. Another important driver to health sector growth is innovation. Business sector investments in R&D and government expenditure on R&D go a long way to improve upon the health sector. Thus the growth theory is supported through the joint effort of VC investments, experienced VC industry, innovation, financial sector development and healthcare infrastructure.

6. Conclusion

The paper seeks to analyse the effect of venture capital investment activities on the growth of the health sector in Europe. We propose that VC investments in healthcare and the age of the VC industry significantly increase health sector growth. The panel analysis carried out in this study covered 23 EU/EEA countries for a period of 20 years spanning 2000 to 2019, using GLS fixed and random effect models after a baseline OLS regression. Investors may record their return on investments, but the social return on VC investments realisable through avenues such as growth in health sector is untenable. The results indicate that VC investments activities in the healthcare sector have improved the health status of the people, such as life expectancy and fertility rate, and, at the same time, reduced death rate. The results suggest that it is not enough to pursue channelling resources into healthcare but this action should be complemented with innovation, financial sector development, macroeconomic factors and healthcare infrastructure, to ensure societal benefits such as health sector growth. This call is very vital in times of unforeseen circumstances such as Covid-19. Venture capital allocation or investment in healthcare increases fertility rate as well as life expectancy and reduces death rate. The age of the VC industry increases health sector growth, suggesting that an experienced VC environment is necessary for health sector growth. This paper acknowledges the role of the government in health sector through healthcare expenditure. Our results thus suggest that a huge venture capital investment has contributed to the growth of the health sector in Europe. We conclude that VC health investment activities do not increase health sector growth in Europe. We further conclude that health sector growth exhibits an elastic relationship with VC investments in healthcare, VC funds as percentage of GDP and per capita expenditure on health.

Although investments will have to be encouraged into the health sector to enable countries to prepare well for unforeseen circumstances like the Covid-19 pandemic, there is also the need to promote social protection investments and healthy lifestyles. Again, we recommend the development of inducement policy models to serve as catalyst for growing the health sector. European governments stand to benefit from the social returns to VC capital investments in healthcare as well as promotion of healthier lifestyles because health sector growth (high life expectancy, increased fertility rate and reduced death rate) positively affect the entire economy. Therefore, we suggest public-private partnerships in healthcare investments as well as well-coordinated and sustained policies and programmes aimed at promoting healthy lifestyles in Europe. Future research may consider cross-country analyses of motivations for VC healthcare investments and sustainability of the industry. The study suffers limitations on data unavailability to allow for some rigorous analyses. Ideally, investigation into possible problems of endogeneity would have helped improve upon the quality of the paper. This is not to cast doubt on the results produced because all the necessary assumptions have been met for the methodology chosen.

Declaration of competing interest

There is no conflict of interest statement to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bir.2021.06.008.

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