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ASSESSMENT OF THE IMPACT OF VENTURE CAPITAL INVESTMENT ON LABOUR PRODUCTIVITY: AN ANALYSIS OF THE EU COUNTRIES

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Abstract. This study investigates the impact of venture capital investments on the labour productivity of the European Union countries. Considering the fact that there is a lack of research on evaluating the effects of venture capital investments on labor productivity at the country level, the methodology designed in this article is used to assess heterogeneous impact of venture capital investments, which is determined by the innovative environment or financial development factors, on labour productivity in 25 EU countries. Panel data of 25 European Union countries were used for the regression analysis. The findings of the empirical study show that the volume of venture capital investments does not determine the growth of labour productivity in the analysed countries. Such results can be explained by the economic findings presented by other researchers. Some of the studies found that it is not venture capital investments that determine economic growth, innovation or technological development, but these economic phenomena increase venture capital investment. Based on statistical data, the greatest need for venture capital investments in Europe is in sectors that develop new technologies and in the information and communication technology sector. Therefore, the volume of venture capital investments in the analysed countries is too small at the macroeconomic level and their effect on labour productivity is manifested at the level of companies or specific sectors.

Keywords: venture capital investment, labour productivity, innovation, financial development, research and development, European Union countries.

JEL Classification: G240, J240, O31.

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1. Introduction

The research covers a relevant and little-studied topic – the impact of venture capital investment on labour productivity in selected countries. Venture capital investments are becoming more and more popular at the global level due to the possible higher profitability, but also the higher riskiness of new or already developed business ideas or products, and they, together with research and experimental development (R&D), are very important in creating countries' innovation and technological progress in selected countries. Innovative start-ups in the advanced technology sector, with high growth potential, often do not comply the criteria set by banks because of the high risks involved. As Matisone and Lace (2021) put it, contrary to banks, venture capital investors tend to assume higher risks. Furthermore, venture capital investments boost financial development in countries, particularly in economically advanced

ones, as new methods of business financing are essential to foster innovation. Recent trends show an increase in the number of companies that are financed by venture capital investments, which is why the volume of venture capital investments is growing (Frimpong et al., 2022). On the grounds of the data of Invest Europe (2021), venture capital investments in Europe in 2021 compared to 2020 grew by more than 70 percent to a record 20 billion EUR volume.

Venture capital investments demonstrate not only their value to investors, but also their potential to enhance overall economic growth and prosperity of the entire economy by promoting a number of rapidly growing companies which generate jobs (Samila & Sorenson, 2011).

By providing not only financial but also intellectual capital to advanced and high-potential companies, venture capital investors have a positive effect on the state economy: technology-based industry develops, the gross domestic product increases, the unemployment rate decreases, new jobs are generated, and the state collects more taxes. All these reasons lead to a rise in the living standards (Pradhan et al., 2019). According to Shahnazi (2021), productivity is one of the most important factors affecting the standard of living, the national welfare, the competitiveness of countries and economic growth. As productivity increases, more output is produced with the same level of input, higher profits are generated, and living standards improve (Heil, 2018). The welfare and prosperity of a country depends on the ability to achieve high productivity and mobilise a large part of the available labour force (Delgado et al., 2012). Differences in labour productivity among countries are linked to the allocation of resources and the need for innovation caused by the transition from the traditional to the technologically advanced sectors (Naveed & Wang, 2023).

Empirical research trends show that researchers are interested in the direct impact of venture capital investments on indicators of economic development (Khan et al., 2021; Karahan, 2016; Faria & Barbosa, 2014; Geronikolaou & Papachristou, 2008). Scholars investigate the connections between venture capital investments and economic growth, technological development, innovations, financial development, financial markets (Pradhan et al., 2017, 2018, 2019; Geronikolaou & Papachristou, 2008). Previous studies have investigated the links between: venture capital investment and economic growth in the context of the digital economy (Pradhan et al., 2019), innovation, financial markets, venture capital investment and economic growth (Pradhan et al., 2018), venture capital investment, financial development and economic growth (Pradhan et al., 2017). Pradhan et al. (2019) declares that more developed countries create new financing instruments (e.g. venture capital investments) to promote the development of risky and innovative companies. The growing digitization of the economy and the rising demand for new information and communication technology products and services have resulted to an increase in the number of new companies in the ICT sector. As a result, there is an increase in the volume of venture capital investments and a concentration from all over the world towards developed regions and countries. Popov and Rosenboom (2013), Geronikolaou and Papachristou (2008) analysed the evaluating of the interaction of venture capital investments determined by other factors on innovation. Research findings show that the impact of venture capital investments on the economic development of countries is not the same; moreover, the results reveal that innovations are determined by the volume of venture capital investments (Karahan, 2016; Geronikolaou & Papachristou, 2008), and not vice versa.

Empirical studies evaluating the effects of venture capital investments on labour productivity were conducted at the company level (Chemmanur et al., 2011; Marti & Alemany,

2006) and sectors (Demmou et al., 2019; Crose et al., 2013). Yet, there is a lack of research works which would assess the impact of venture capital investments on the country's labour productivity or the links between venture capital investments and other factors determining labour productivity. The lack of research works on the impact of venture capital investments at the level of countries is identified as being revealed and highlighted in the studies conducted by the following scholars: Khan et al. (2021), Karahan (2016), Faria and Barbosa (2014), Popov and Roosenboom (2013), Pottelsberghe and Romain (2004). Poelhekke and Wache (2023) emphasize that a large of literature examines the evaluating of venture capital investments on firm-level activities, but their effects on macroeconomics indicator indicator (such as economic growth, employment) are less well understood. This research follows this line of thinking and aims to assess the impact of venture capital investments on labour productivity in the European Union countries. This identicied research originality and fills the gaps in the fields research of venture capital and labour productivity. The novelty of this study is to perform a multifaceted assessment of the impact of venture capital investments on labour productivity and to determine whether the volume of venture capital investments leads to the growth of labour productivity at the country level. The connection and specificity of the phenomena of venture capital investments and the country's labour productivity is a novel and innovative object of research.

The originality of this research is distinguished by the fact that, depending on the interaction of venture capital investments with other country-level indicators, the impact of venture capital investments on labour productivity growth in countries can be heterogeneous. The effect may vary depending on the country's innovation environment and financial development. In the present study assessing the impact of venture capital investment on labour productivity was employed an originally designed research methodology, when multiple regression analysis was applied using the panel data of EU-25 countries for a period of 2007–2019. Empirical research was conducted in 25 countries of the European Union including the United Kingdom because UK was in the EU during the analysed period: Sweden, Finland, Ireland, Denmark, Luxembourg, United Kingdom, Greece, Netherlands, Belgium, France, Germany, Austria, Spain, Estonia, Portugal, Hungary, Italy, Latvia, Lithuania, Czechia, Slovakia, Poland, Slovenia, Bulgaria and Romania.

The rest of the paper is organised as follows. Section 2 literature review. Section 3 shows research the applied methodology. Section 4 presents empirical results. Section 5 discusses the result and a robustness check of the results of the empirical study was performed. Section 6 conclusions and directions for future research.

2. Literature review

2.1. Research analysis of venture capital investments

In this part, a detailed analysis of the scholarly literature on the research studies assessing the impact of venture capital investments on economic development and their results was carried out. Scientists emphasise that in order to increase the long-term innovative capacity and competitiveness of the country's economy, it is necessary to use venture capital investments. In the context of globalisation, innovation is the main source of competitiveness of countries (Karahan, 2016). According to Makomaski and Johansson (2013), venture capital investments are significant for the growth of developed and developing economies. Venture capital investments are an extremely important role in supporting technological innovation (Wang et al., 2023). Venture capital investments promote technological progress and have a positive effect

on the development of companies, the country's economy and competitiveness, thereby creating added value and promoting the development of the high-tech sector (Schofer & Leitinger, 2002). It has been proven that access to a source of financing determines the creation of a new business (Popov & Roosenboom, 2013; Aghion et al., 2007), its growth (Aghion et al., 2007), especially for innovative ones (Lee et al. 2015) and for companies based on new technologies (Revest & Sapio, 2012). According to Aghion et al. (2007), access to a source of finance helps companies grow and expand. Based on research, venture capital investments are suitable for new companies (Popov & Roosenboom, 2013) and can be targeted for new technology-based companies, which are classified as a subgroup of innovative companies (Revest & Sapio, 2012) associated with high risk. Karahan (2016) has it that innovations are boosted by the emergence of technology-intensive firms, which tend to be young and entrepreneurial. Technology-intensive companies have a positive impact on the economies of developed countries. High-tech companies and their investments are necessary for economic development based on productivity growth. In this way, an innovation-based economy is created in the country. Current research focus: the impact of venture capital investments on the artificial intelligence sector (Montanaro et al., 2024) or the digital economy (Li et al., 2024).

Venture capital investment as a financing tool can stimulate economic growth by providing opportunities for companies to access a source of business financing. This is associated with higher productivity, competitiveness and economic growth. According to Popov and Roosenboom (2013), access to a source of financing is a significant factor that determines the creation and growth of a new business. Lerner and Tag (2013) add that economic growth is determined by innovations created by young companies which are characteristic of high operational risk. Companies that obtain venture capital investments are significantly more innovative compared to those that do not (Sun et al., 2020). It has been found that companies financed by venture capital investments grow faster, generate more patent applications and have higher productivity than those that did not receive these investments (Croce et al., 2013). The positive impact of venture capital investments has been assessed for changes in the volume of sales and employment of companies (Bertoni et al., 2011).

A research study by Pottelsberghe and Romain (2004) assessed the impact of venture capital investment on economic growth in terms of productivity in OECD countries. It aimed to determine whether countries with a higher volume of venture capital investments have a higher impact on the level of productivity. According to the authors of this article, a reciprocal relationship can form, because the volume of attracted venture capital investments may be higher in countries with higher productivity. The present research attempts to find out whether the effect of venture capital investment on productivity manifests through interaction with other factors: 1) innovations, achieved by successfully introduction new products and processes into the market when venture capital investments are equated to R&D costs, and 2) absorptive capacity, increasing the development of knowledge of private companies and public research institutions, thus forming opportunities to start experimental development. The research model is based on the traditional Cobb-Douglas production function: $Y = f(L, K)$, where Y is production volume; L is labour force; K is capital. In the Cobb-Douglas function, venture capital is included as an additional source of knowledge that determines economic growth. In addition, various sources of technical change are considered, including business and public expenditure on R&D. In terms of absorptive capacity, venture capital investments promote the efficient use of knowledge in improving the production system. This effect is more indirect, as activities financed by venture capital investments can be equated with intensive learning processes, which lead to rapid and effective absorbtion of external knowledge.

In addition, higher volume of venture capital investments strengthens the economic impact of R&D, increases the channeling of knowledge to new products and processes. A research study by Pottelsberghe and Romain (2004) found that the social return of venture capital investment is significantly higher than that of R&D. This shows that venture capital investment determines economic growth due to the interaction with both factors – innovations and R&D.

2.2. Analysis of empirical research on the impact of venture capital investments on labour productivity

Empirical research studies assessed the relationship between venture capital investments and labour productivity (Marti & Alemany, 2006; Chemmanur et al., 2011; Crose et al., 2013; Demou et al., 2019). Marti and Alemany (2006) studied 518 Spanish companies to assess the impact of venture capital investment on labour productivity. They found venture capital investment to be one of the key drivers of innovations and increase of labour productivity. According to them, the environment created at the political level promotes the development of the venture capital sector, which in the long run leads to greater competitiveness of the economy. Chemmanur et al. (2011) conducted a research study of over 187,000 private manufacturing companies in the USA and found that labour productivity was increasing for four years after venture capital investments were made, and it remains at that level until the investors exit. Crose et al. (2013) continue the scientific discussion on the impact of venture capital investment on productivity in European countries over the period of 1995–2004. The empirical research included 696 business enterprises operating in the high-tech industrial sector in European countries (Belgium, Finland, France, Italy, Spain and Great Britain), of which 267 received venture capital investments. The results of the study showed that labour productivity was higher in companies whose activities were financed by venture capital investments. Demmou et al. (2019) conducted an empirical research in 32 countries and a group of 30 industries between 1990 and 2014, investigating the relationship between labour productivity and the financial system in intangible asset-intensive sectors. In their study, the effect of individual indicators measuring financial development on labour productivity was investigated and the effect of financial development on labour productivity was assessed through interactions. The results showed that the effect of financial development on the growth of labour productivity was significant, and when assessing the interactions of venture capital investments with the intensity of the intangible asset-intensive sector, the effect on labour productivity was positive, though statistically insignificant.

Decisions made at the political level create other alternative sources of corporate financing, one of them being venture capital investments. The policy and institutional environment have an additional impact on the availability of funding sources. The country's financial development makes it possible to reduce the friction due to companies' dependence on external financing, as well as to reduce the cost of credit and distribute the sources of external funds available to companies. According to Demmou et al. (2019), the link between venture capital investment and labour productivity growth is formed in countries when the following are being promoted:

- financial development, the impact of which on productivity growth is stronger in the presence of certain corporate financing instruments, i.e. with better access to stock markets and venture capital investments. In developed countries and in an economy based on innovations, the choice of such forms of financing as venture capital investments becomes extremely significant;

- greater competition in the banking sector, especially in less financially developed countries. This means that bank competition should promote the growth of labour productivity in less financially developed countries;
- liberalised, open and stable financial markets, especially in financially well-developed countries, which are open markets for foreign investors, thereby promoting productivity growth in the most innovative sectors;
- easy access to information about credit volumes, requirements, etc., increases productivity in financially developed countries in intangible asset-intensive sectors.

Credit transparency can be particularly useful for small businesses seeking to demonstrate the quality of their business to investors.

2.3. Analysis of empirical research on the impact of venture capital investments on labour productivity in the macro level

This subsection presents the rationale why it is important to conduct empirical research on the impact of venture capital investments on labor productivity in the macro level. As was mentioned in introduction, researchers are purposefully emphasising venture capital investment research at the country level, thereby expanding and closing this research gap (Khan et al., 2021; Karahan, 2016; Faria & Barbosa, 2014; Popov & Roosenboom, 2013; Pottelsberghe & Romain, 2004). Khan et al. (2021), and Pradhan et al. (2017) emphasize that researching venture capital investments at both the company and country levels is of fundamental importance.

Popov and Roosenboom (2013) add to a specifically limited field of the impact of venture capital investment on economic growth but not on company's performance results and, in such a way, contribute to research works conducted at country levels. Faria and Barbosa (2014) expanded the field of scientific investigation on the impact of venture capital investment on country-wide innovations. According to Karahan (2016), in a macroeconomic view, it is necessary to expand the field of scientific investigations on interaction between venture capital investment and innovations. Their research develops and focuses attention on correlation among venture capital investment and innovations as well as economic results at a country level. Research studies conducted by Pradhan et al. (2017, 2018, 2019) found the correlation between venture capital investment and macro-level factors in Europe. This demonstrates even a higher demand for research to be conducted at national levels. Pottelsberghe and Romain (2004) have it that the effect of venture capital investment on economic growth in the aspect of productivity has not been assessed. Geronikolaou and Papachristou (2008) have it that the research conducted in the USA in 2003 by Ueda, Hirukawa contradicted the view that venture capital investment is a cause of innovations. The researchers found that a reciprocal correlation exists in countries ranging from innovations to venture capital investment, and this could have impacted by a large "wave" of innovations that created business opportunities and demand for funding by venture capital.

To sum up, the conducted research studies on the impact of venture capital investments on economic development do not provide an extensive assessment of the impact of venture capital investments on the growth of labour productivity in selected countries. It has been found that insufficient attention was paid to research on the impact of venture capital investments at the country level; therefore, the researchers emphasise the need not to limit the research to the level of companies or sectors. Conducting such research at the country level is significant, as venture capital investments are related to the country's innovations, research

and experimental development, technological and financial development. A new and relevant field of research is emerging, the purpose of which includes the assessment of the impact of venture capital investments on the labour productivity of countries.

3. Research methodology

3.1. Substantiation of the methodology for assessing the impact of venture capital investments on the country's labour productivity

This study expands and complements the field of scientific research on the assessment of the impact of venture capital investments on the labour productivity of countries. Based on the literature analysis, it was found that researchers in their empirical studies analyse the impact of venture capital investments on indicators of economic development; therefore, a direct correlation between venture capital investments and labour productivity may appear at the macroeconomic level.

In the context of theories on economic growth, the connection of venture capital investments with labour productivity in terms of innovation (Schumpeter, 1949; Romer, 1990), technological changes (Romer, 1990) and knowledge and R&D (Solow, 1956; Schumpeter, 1949; Romer, 1986) has been revealed. The research methods are based on these theories and the connection of factors determining labour productivity to venture capital investments.

After carrying out the empirical research analysis, it was found that mostly analysed factors are those determining labour productivity: innovations, development of information and communication technologies, financial development, financial openness, inflation, foreign trade, human capital, supply of labour with capital (Padgureckienė, 2024). According to the authors of the present study, from an economic perspective, venture capital investments can be classified as factors that indirectly determine labour productivity, their impact on labour productivity manifests itself through the influence of direct impact factors; therefore, assessment of the impact can include the assessment of the correlation of *several independent variables*. Based on the analysis of scientific literature, it was found that venture capital investments are associated with innovations and financial development (Khan et al., 2021; Pradhan et al., 2018, 2017; Karahan, 2016; Faria & Barbosa, 2014; Geronikolaou & Papachristou, 2008). An innovative environment requires access to funding sources, which creates the prerequisites for achieving significant results related to the pursuit of innovative goals, the ability to mobilise financial resources for research and experimental and technological development. Financial development is a part of economic growth related to the financing of innovation and entrepreneurship. Venture capital investments are an alternative source of business financing that determines the country's financial development. Considering the fact that venture capital investments are linked to the country's innovative environment and financial development, it is appropriate to carry out assessment of *the heterogeneous* impact of venture capital investments, the decisive factors of the innovative environment and financial development, on labour productivity.

The study includes two stages: (i) assessment of the impact of venture capital investments determinaned by the innovation environment, and (ii) financial development factors as impacting labour productivity. To ensure the robustness of the results achieved during the empirical research according to the formed regression equation, a robustness check of the results of the empirical study was performed.

3.2. Model specification and data

The study period covers 2007–2019, as data on venture capital investments in the OECD database is available from 2007 onwards. The research sample consists of the 25 countries of the European Union, as the OECD database does not contain statistical data on venture capital investments in Cyprus, Croatia and Malta. The study presents data up to 2019, as more recent data at the beginning of the study period were not fully available. Descriptive statistics of selected variables are presented in Appendix, Table A1. Statistical data used for the empirical research was collected from: World Bank, OECD, UNCTAD, Eurostat, Fraser Institute and International Monetary Fund databases.

In order to assess the impact of venture capital investments on the growth of labour productivity, an econometric multiple regression model was designed. The impact of venture capital investments on the labour productivity of countries determined by the innovative environment and financial development is studied; therefore, the interactions are included in the regression equation. A regression equation is presented for examining the *heterogeneous impact* of venture capital investment on labour productivity of countries:

$$\Delta \ln\left(LP_{i,t}\right) = \alpha + \beta_1 \times \ln\left(VCI_{i,t}\right) + \delta \times \ln\left(VCI_{i,t}\right) \times X_{i,t} + c_0 \times X_{i,t} + c_1 \times \ln\left(LP_{i,t-1}\right) + c_2 \times \Delta\left(FDI_{i,t}\right) + c_3 \times \Delta\left(INF_{i,t}\right) + c_4 \times \ln\left(OPENN_{i,t}\right) + c_5 \times \ln\left(EDUC_{i,t}\right) + c_6 \times \ln\left(KL_{i,t}\right) + c_7 \times LMR_{i,t} + \theta_t + \mu_i + \varepsilon_{i,t},$$

where i – country, t – time period, α – constant, θ_t – the represented time effects, μ_i – specific effects which do not change in relation to time for each country, $\varepsilon_{i,t}$ – bias of the regression equation, Δ – change over one period, ln – natural logarithm, $\Delta\ln(LP_{i,t})$ – average two-year labour productivity growth over time period t in country i, $\ln(VCI_{i,t})$ – volumes of venture capital investment over time period t in country i, X – the indicator for making the interaction of venture capital investments, c_0 – coefficient showing the effect of indicator $\boldsymbol{X}$, $\ln(LP_{i,t-1})$ – labour productivity level for the earlier (i.e., initial) years over time period t in country i, $\Delta(FDI_{i,t})$ – a foreign direct investment flow over time period t in country i, $INF_{i,t}$ – therate of inflation over time period t in country i ($\Delta\ln CPI \times 100$), $\ln(OPENN_{i,t})$ – the rate of openness of trade over time period t in country i, $\ln(EDUC_{i,t})$ – the rate of higher education over time period t in country i, $\ln(KL_{i,t})$ – the rate of provision with capital over time period t in country i, $LMR_{i,t}$ – the rate of provision with capital over time period t in country i.

LP is a dependent variable expressed in the growth rate of labour productivity. This is done in order to reduce the impact of business cycles; therefore, the empirical part calculates the average growth rate of labour productivity for two years. Statistics on venture capital investments (*VCI*) as a percentage of gross domestic product are taken from the Organization for Economic Co-operation and Development. The research uses this mostly in research studies (Pradhan et al., 2017, 2018, 2019; Demmou et al., 2019; Grilli et al., 2019; Groh et al., 2016; Pottelsberghe & Romain, 2004) included indicator of venture capital investment at the country level. Empirical studies have mostly used and determined the strengthening effect of innovation on labour productivity, expressed as expenses for scientific research and experimental development. For this reason, the research measures the innovation environment by the R&D expenditure indicator (*RD_B*) of the business sector. Expenditures allocated to this area represent business investments in innovative performance, which lead to higher venture capital investments. Venture capital investments strengthen the economic impact of R&D by channeling knowledge into new products and processes (Pottelsberghe & Romain,

2004). The study assesses the impact of venture capital investments on labour productivity together with the indicator of the bank credit for the private sector (*BANK*), which identifies financial development. According to Colombo and Murtinu (2014), Lerner and Tag (2013), venture capital investments are an alternative source of business financing. Pradhan et al. (2018) emphasise that venture capital investments are necessary for innovative companies, as their funding presents too much risk for traditional financial institutions. Venture capital investments replace or supplement bank loans.

The research hypotheses:

H1. *The impact of venture capital investments on the labour productivity of the EU countries depends on the innovation environment of the country.*

The study aims to assess whether venture capital investment's effect on labour productivity gets stronger when it is determined by business sector spending on R&D.

H2. *The impact of venture capital investments on the labour productivity of the EU countries depends on the financial development of the country.*

Assessed whether the impact of venture capital investments on labour productivity weakens when bank credit to the private sector is decisive.

Researchers include an indicator of past labour productivity (*LP* – 1) in empirical studies to determine whether convergence exists between them (Demmou et al., 2019). The control factors determining the growth of labour productivity are reflected by the change in accumulated inward foreign direct investment, the inflation rate (percent), trade openness, expressed as the amount of export and import (percentage from the GDP), higher education, measured as the percentage of people who have obtained higher education, the labour force capital supply, calculated by the volume of total fixed capital per employed person, and the quality of institutions, expressed by the labour market flexibility index.

According to the research methodology, using the GRETL software package, the results of the performed general significance, Breusch-Pegan and Hausman tests showed that the most suitable method is that of the fixed effects. The study uses *least-squares dummy variables* (LSDV) to calculate estimates as a substitute for the fixed effects method. *Time dummies* are included in the formed regression equations, which absorb the effect of time on the results of the study (Wooldridge, 2003). After carrying out the regression analysis, the confidence intervals were calculated. Pradhan et al. (2017) investigating the relationship between venture capital investment in European countries characterised by financial development and economic growth found that the calculation of confidence intervals indicates the accuracy and reliability of statistical inferences. Their study uses a 95 percent confidence interval. In country-level studies that assess the interaction effects of venture capital investments with other indicators, the formation of confidence intervals is an appropriate way *to formulate statistical conclusions*. Based on the calculated slopes, the study assesses the impact of venture capital investments on labour productivity and summarises the results. The impact of venture capital investments conditioned by the innovative environment and financial development factors is statistically significant if the calculated value of the slope is greater than 1.96. Regression equation coefficient estimates, their variations and covariances (Friedrich, 1982) are used.

To sum up, the research methodology is comprehensive and includs several aspects of impact. Based on it, two stages of empirical research have been formed and logical consistency has been defined. According to the presented methodology, the third part of the article assesses whether the volume of venture capital investments, determined by the innovative

environment and financial development factors, has a greater impact on the labour productivity growth rate for 25 European Union countries.

4. Empirical results

The assessment of the direct impact of venture capital investments on labour productivity growth in 25 European Union countries was carried out by Padgureckienė (2023). The results of the study showed that the volume of venture capital investments does not determine the growth of labour productivity. First of all in this study assesses the impact of venture capital investments, which are determined by R&D expenditures of the business sector, on the growth of labour productivity (see Table 1).

Table 1. The impact of venture capital investments on labour productivity determined by the innovation environment in the EU-25 countries (source: calculated by the authors)

Innovation environment determined by R&D expenditures of the business sector (ln*RD_B*)	
Constant	1.545***
	(0.3803)
Venture capital investments	–0.0005
	(0.0031)
Venture capital investments x innovation environment	0.0002
	(0.0018)
Innovation environment	0.0029
	(0.0085)
Labour productivity rate (lnLP_{t-1})	–0.1446***
	(0.0345)
Foreign direct investments (*d FDI*)	–4.695e-05
	(5.303e-05)
Inflation (*INFL*)	–0.0002
	(0.001)
Trade openness (ln*OPENN*)	0.011
	(0.0187)
Higher education (ln*EDUC*)	0.0004
	(0.0196)
Labour supply with capital (ln*KL*)	0.0086
	(0.0118)
Labour market regulation (*LMR*)	–0.0059*
	(0.0033)
n	325
Corrected R^2	0.6836
Data diagnostics:	
White test	p < 0.05
Wooldridge test	p < 0.05
Pesaran test	p > 0.05

Note: *p < 0.10, **p < 0.05, ***p < 0.01.

According to the analysis of the scientific literature, it can be stated that higher-risk venture capital investments strengthen the economic effecct of R&D on productivity (Pottelsberghe & Romain, 2004). The results of the empirical study show that venture capital investments determined by business sector expenditures on R&D have no effect on the growth of labour productivity. Based on the insights of the authors and Coccia's (2018) study, it can be assumed that the introduction of innovations and the application of innovative technologies, rather than R&D expenditures, lead to labour productivity growth. The obtained results show that the lower the current level of labour productivity, the greater the possibilities of its growth in the future, this reflects the convergence of labour productivity growth in the sample of EU-25 countries.

Table 2 presents an assessment of the impact of venture capital investments, which are the determinants of banks' internal credit for the private sector, on labour productivity growth.

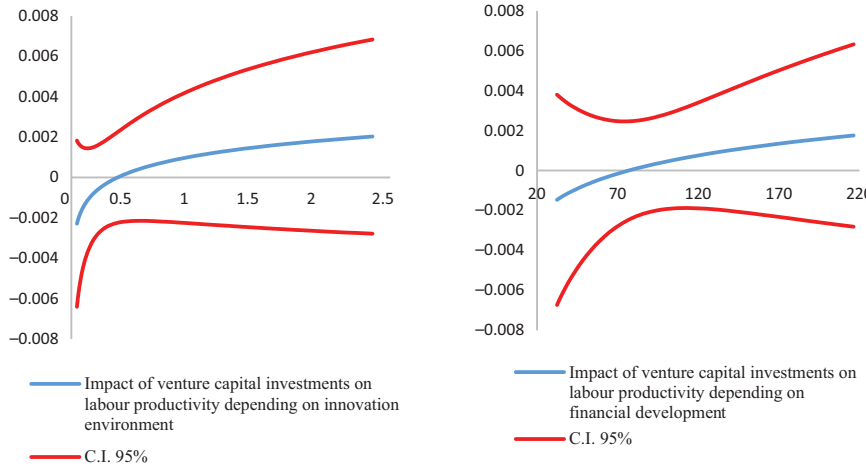
Table 2. The impact of venture capital investments on labour productivity, determined by financial development in the EU-25 countries (source: calculated by the authors)

Financial development is measured by a bank credit for the private sector (ln BANK)	
Constant	1.522***
	(0.3334)
Venture capital investments	0.0175
	(0.0103)
Venture capital investments x financial development	–0.0041
	(0.0024)
Financial development	–0.029***
	(0.0101)
Labour productivity rate ($\ln LP_{t-1}$)	–0.1186***
	(0.0309)
Foreign direct investments (*d FDI*)	–5.893e-05
	(6.650e-05)
Inflation (*INFL*)	–0.0006
	(0.001)
Trade openness (ln*OPENN*)	0.0144
	(0.0187)
Higher education (ln*EDUC*)	0.0042
	(0.0201)
Labour supply with capital (ln*KL*)	–0.0042
	(0.0104)
Labour market regulation (*LMR*)	–0.0075*
	(0.0042)
N	325
Corrected R^2	0.6121
Data diagnostics:	
White test	$p < 0.05$
Wooldridge test	$p < 0.05$
Pesaran test	$p > 0.05$

Note: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

As can be seen from Table 2, the interaction of venture capital investment with bank credit for the private sector is not significant for the growth of labour productivity. It can be stated that, in the 25 countries of the European Union, financial development is rapid, and venture capital investments, which are the determining factors moderating financial development, do not weaken the impact on the growth of labour productivity of the selected countries.

Based on the calculated confidence intervals, Figure 1 presents information when the impact of venture capital investments on the growth of countries' labour productivity is determined by the indicator of innovation environment or financial development. Confidence intervals (red lines) show the true value with estimated errors. The calculated slope (blue line) shows the relative impact of venture capital investment on labour productivity, i.e the direction and strength of the impact of venture capital investment with the corresponding combination of innovation environment or financial development. Part a) of Figure 1 shows the impact which is determined by business sector spending on research and experimental development, part b) is determined by bank credit for the private sector.



a) b)

Note: X-axis is: a – R&D expenditure of the business sector; b – internal credit of banks for the private sector; Y-axis is the coefficient of elasticity of venture capital investment to labour productivity.

Figure 1. The impact of venture capital investments on labour productivity is determined by: a – the innovative environment, which is measured by the R&D expenditure of the business sector; b – financial development, which is measured by the internal credit of banks for the private sector

The obtained results show that venture capital investments which are determined by the innovative environment measured by the R&D expenditures of the business sector do not have a significant impact on the growth of labour productivity. Based on the analysis of theoretical and empirical research, it can be stated that there is a reciprocal relationship between venture capital investments and business sector expenditures on R&D, where innovation is not only a consequence of venture capital, but most likely a cause (Popov & Rosenboom, 2013; Geronikolaou & Papachristou, 2008). The calculated confidence intervals and slopes reveal that the impact of venture capital investment, which is determined by financial development which is expressed in the amount of bank credit for the private sector, on labour productivity growth is insignificant.

5. Discussion

To check the robustness of the model, modifications were made to the model by changing the variables with alternative measurement methods:

- innovative environment factors,
- financial development factors.

Next, the innovation environment and financial development variables are modified. In empirical research, the impact of innovations on labour productivity expressed by an index of patents is assessed (Dua & Garg, 2019). Khan et al. (2021) have it that patents indicate the results of company's innovation processes and are a suitable measure unit; therefore, the research included a number of patents per 1,000 inhabitants. Grounding on the "Invest Europe" (2021), Gabison (2015) data, almost half of venture capital investment is allocated to the information and communication technologies sector. It has been proven that venture capital investment determines the development of sectors operating on the basis of new technologies and innovations (Frimpong et al., 2022; Khan et al., 2021). In the research, an indicator of employment in technology and knowledge intensive sectors is included in the innovative environment. It demonstrates how much country's economy is oriented towards production of value-adding goods and provision of such services. The research includes two indexes of the IMF: effectiveness of financial institutions and financial markets, which combine several aspects of financial development. These indexes demonstrate effectiveness of services provided by financial institutions and financial markets (Svirydzenka, 2016). The research results coincide when the innovation environment and financial development are expressed by three options (Appendix, Table A2). It can be declared that the modifications of the model had no impact on the results of the model because the results of the effect of venture capital investment on assessed labour productivity growth in them are the same.

6. Conclusions

The analysis of scientific research on the impact of venture capital investments on labour productivity has revealed that the research in this area is limited to the company and sector levels. On the basis of the analysed empirical research results, it was found that the impact of venture capital investments on labour productivity is manifested in companies that were financed by venture capital investments rather than in the conventionally financed companies. Also, it was observed in the sectors where the need for venture capital investments and the lack of funding were the greatest. Scholars unanimously agree that it is necessary to extend the scope of this research and to conduct investigation on the impact of venture capital investments across countries, instead of merely exploring at the company or sector level.

It was found that the impact of venture capital investments on labour productivity can be determined by factors of innovation and financial development. The impact of these factors on labour productivity of the countries was analysed by other researchers, and their significance and direction of impact were shown in empirical studies. However, the research studies did not analyse the impact of the interaction of venture capital investments with the innovative environment and financial development factors. The present study assesses the impact of venture capital investments, determined by the innovative environment and financial development factors, on the growth of labour productivity at the country level.

The empirical study was conducted based on the designed methodology for assessing the impact of venture capital investments on labour productivity, the results of which show that

the impact of venture capital investments on labour productivity in the EU-25 is statistically insignificant. Research hypotheses was rejected. Such research results could be determined by the aspects emphasised in other studies: 1) the reciprocal relationship between venture capital investments and labour productivity, since the volumes of attracted venture capital investments may be higher in countries with higher productivity levels, 2) the volumes of venture capital investments at the country level are relatively small, 3) no significant impact of venture capital investments, caused by the innovative environment and financial development factors, was found, as their impact on the growth of labour productivity can appear separately or overlap with each other.

It is understandable that the results of this research have certain limitations. In order to compare the research results obtained in the empirical article part with the results of other researchers, there is a lack of such comparisons because the impact of venture capital investments on labour productivity at the country level has not been studied. In the study, it was decided not to single out a separate group of factors dedicated to the technological development, but rather to assign it to the innovative environment because groups of these factors are treated as identical in empirical research works.

The development of research may involve the inclusion of other environments, for example, by further factors identifying technological, entrepreneurial or institutional environments in greater detail. The analysis of the research could be continued by drawing proposals for countries regarding the development of labour productivity and the scope of venture capital investments. It has been proven that it is not venture capital investments that lead to economic growth, innovation or technological development, whereas these economic phenomena result in a rise in venture capital investments. Therefore, it would be possible to assess whether the increase of labour productivity determines the volume of venture capital investments. At the macroeconomic level, the research can be further developed in countries with poorly developed financial markets and likely low volumes of venture capital investments.

The methodology developed in the study can be practical applied in different countries or groups of countries. The practical implications of the research results can be important and practically used by for public authorities, who creating innovation policy and making decisions on the development of the venture capital sector and forming operational guidelines and recommendations for increasing the volume of venture capital investments in countries.

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APPENDIX

Table A1. Descriptive statistics

Marking	Data base	Min	Max	Mean	Median	Standard deviation
LP	World Bank, OECD	–0.0553	0.124	0.00870	0.00760	0.0196
VCI_1000	OECD	0.000	1.01e+005	12399	6973.8	14652
VCI_GDP	World Bank, OECD	0.0000	0.129	0.0288	0.0249	0.0252
VCI_GFC		0.000	0.569	0.124	0.0993	0.112
FDI	UNCSTAD	9.09	376	66.6	47.0	64.4
INFL	World Bank	–4.48	15.4	1.97	1.73	2.11
OPENN		45.4	408	120	104	64.4
EDUC	Eurostat	12.0	47.3	29.7	30.2	8.58
KL	World Bank, OECD	2762.8	83713	14991	1316	10254
LMG	Fraser institutas	3.89	8.40	6.62	6.77	0.991
RD_B	Eurostat	0.0433	2.40	0.783	0.539	0.641
BANK	World Bank	32.4	201	91.2	88.5	39.7
PATENT	World Bank	0.000	0.0600	0.0138	0.00832	0.0127
EMPL	Eurostat	1.70	8.50	4.10	4.00	1.28
IE	International Monetary Fund	0.368	0.815	0.620	0.626	0.0802
ME		0.000	1.00	0.522	0.553	0.394

Table A2. Stability check of the research results. Impact of venture capital investments on labour oproductivity, depending on innovation enviroment or financial development, in EU-25 countries

	The innovation environment is measured by:		Financial development is measured by:	
	patents (ln PATENT)	employment in technology- and knowledge-intensive sectors (ln EMPL)	the efficiency of financial institutions (IE)	the efficiency of financial markets (ME)
Constant	1.861***	1.700***	1.628***	1.520***
	(0.3642)	(0.3640)	(0.2901)	(0.3426)
Venture capital investments	–0.0009560	–0.0002578	0.01388	–0.0007998
	(0.001669)	(0.001283)	(0.01760)	(0.001665)
Venture capital investments x innovation environment or financial development	0.0001416	0.0004038	–0.02451	–0.0005486
	(0.0005608)	(0.0005094)	(0.02853)	(0.003241)
Innovation environment or financial development	–0.007646**	0.03138**	–0.07426	–0.005472
	(0.003370)	(0.01425)	(0.1062)	(0.01782)

End of Table A2

	The innovation environment is measured by:		Financial development is measured by:	
	patents (ln PATENT)	employment in technology- and knowledge-intensive sectors (ln EMPL)	the efficiency of financial institutions (IE)	the efficiency of financial markets (ME)
Labour productivity rate (lnLP_{t-1})	–0.1674***	–0.1619***	–0.1283***	–0.1415***
	(0.03579)	(0.03326)	(0.04157)	(0.03040)
Foreign direct investments (*d FDI*)	–7.958e-06	–3.759e-05	–4.064e-05	–4.901e-05
	(2.021e-05)	(5.706e-05)	(4.769e-05)	(5.672e-05)
Inflation (*INFL*)	–0.001089*	6.920e-05	–0.0004302	–0.0003469
	(0.0005571)	(0.0009589)	(0.0008011)	(0.001040)
Trade openness (ln*OPENN*)	0.003472	0.008389	0.01125	0.01216
	(0.01597)	(0.01890)	(0.01787)	(0.01923)
Higher education (ln*EDUC*)	0.009567	–0.009470	–0.009993	0.0001953
	(0.01905)	(0.01854)	(0.02286)	(0.01898)
Labour supply with capital (ln*KL*)	–0.001317	0.01241	–0.007916	0.007577
	(0.008690)	(0.01258)	(0.01460)	(0.01120)
Labour market regulation (*LMR*)	–0.003285*	–0.005615*	–0.006681*	–0.006043*
	(0.001876)	(0.003193)	(0.003649)	(0.003395)
n	325	325	325	325
Corrected R^2	0.7844	0.6924	0.6325	0.6135
Data diagnostics:				
White test	$p < 0.05$			
Wooldridge test	$p < 0.05$			
Pesaran test	$p > 0.05$			

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.