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Does economic policy uncertainty affect venture capital investments for OECD countries?

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ABSTRACT

Economic policy uncertainty (EPU) has significant effects on the real economy. Therefore, this study aims to investigate the effects of economic policy uncertainty on venture capital, a special financing form. In this study, the effects of economic uncertainty on venture capital for 14 OECD countries are investigated between 2007 and 2020 years. The results show that the increase in economic uncertainty in the long term increases venture capital investments in developed countries. The contributions of the study are demonstrating how venture capital reacts to economic policy uncertainty and using up-to-date methods that allow soft transitions to studying long-term relations between series.

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1. Introduction

Venture capital (VC) is an essential financial complementary to developing advanced technology businesses. However, VC investment behavior has been primarily affected by the concentration of economic uncertainty (Yi et al. 2022). In other words, high economic uncertainty is known to restrict companies' desires to provide employment and make investments and reduce consumers' desires to spend (Bloom 2014; Baker, Bloom, and Davis 2016). In recent years, the economic environment has been complex and volatile. Investments are highly sensitive to the impact of the macroeconomic environment. Economic policies are direct macroeconomic regulation tools. Adjusting the economic policy is of great importance as it will ultimately be reflected in the firm's investment decisions (Liu et al. 2020). In this context, this study aims to investigate the effects of economic policy uncertainty on venture capital investments for 14 OECD countries.

Scientific interest in financing innovation to mitigate climate change has recently increased significantly. In 2015, 95 countries signed the climate agreement at the COP 21 meeting in Paris. The United Nations Convention on Climate Change addresses key areas needed to combat climate change. It defines climate finance as an effective tool for mitigation through public, private and alternative sources of finance (Bianchini and Croce

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2022). Venture capital investments in clean technology have undergone a significant change in recent years. Countries have taken important steps to achieve the goal of green growth and zero carbon emissions. To do this, countries have begun to focus on activities to develop clean technologies and renewable energy infrastructures. However, current support for clean energy innovation to achieve a low-carbon economy remains well below what is needed. In this context, venture capital can play a game-changing role in accelerating the ongoing global energy transitions (Maiti 2022).

Uncertainty is a vast concept ranging from macro and micro phenomena to non-economic ones. Economic uncertainty includes the uncertainties encountered in macro and micro phenomena. In this respect, both macro and micro uncertainty, especially in economic recession times, tend to increase sharply while showing a downward trend in economic revival times. Wars, oil price spikes, financial panics, and exogenous shock types that may cause recession are significant factors that increase uncertainty (Bloom, 2014). EPU covers uncertainty related to money, finance, trade, and other macroeconomic policies. Therefore, EPU is considered an important parameter for economic units. In addition, the EPU can affect CO2 emissions in many ways. The increase in EPU acts as a deterrent to investment and production and can therefore reduce CO2 emissions. On the contrary, the increase in EPU affects technology, innovations and renewable energy consumption. This can intensify CO2 emissions. Thus, EPU can create two effects, increasing or decreasing CO2 emissions (Syed and Bouri 2020).

As policies affect the ecosystem of firms, the risk associated with overall economic policy directly or indirectly affects corporate decisions, investments and profitability (He, Ma, and Zhang 2020). In this context, real options theory under uncertainty predicts a "wait and see" strategy (Huang, Wu, and Guo 2022). The possible effects of economic policy uncertainty are discussed from two perspectives. First, an increase in economic policy uncertainty makes the firm more willing to wait for the most appropriate investment opportunity. Therefore, the greater the uncertainty, the higher the return on investment of the enterprise. Second, for businesses, the stability of the policy environment creates a more conducive environment for increasing business profitability. In other words, the lower the uncertainty of the economic policy, the higher the profitability (Guo et al. 2020). The growth option theory of investment analyzes the cost-benefit of investment behavior from a "good news" and "bad news" perspective. The good news effect suggests that investment spending by businesses increases with the increase in economic policy uncertainty. In addition, the theory assumes a positive growth option effect. The bad news effect is associated with negative innovations in macroeconomic quantities (e.g., output, consumption, earnings) and lower investment (Guo et al. 2020; Segal, Shaliastovich, and Yaron 2015).

Companies temporarily resort to suspending their investments and hiring processes in high uncertainty periods (Bloom 2009). In other words, uncertainty causes investors to be on the safe side regarding their investment behaviors and wait until the uncertainty decreases. Venture capital investments are regarded as partly reverseless. Therefore, venture capital investors want to wait for new information about portfolio companies and the investment environment before providing finance. However, uncertainty will increase the value of waiting and encourage delaying VC investments. As a result, increased EPU will increase in the period between venture capital finance. In that regard, venture capital investors are assumed to show a delaying tendency for investments in

high economic policy uncertainty times. Most studies in the literature suggest that there is a negative relationship between uncertainty and investment (Huang, Wu, and Guo 2022). For instance, Bonini and Alkan (2012) showed that low political risk on a company basis triggers higher VC investments in their studies for the first time. On the other hand, there is also a mechanism named "growth options" in which uncertainty may positively impact investment (Huang, Wu, and Guo 2022). Some companies with a more uncertain future are more willing to make novelties. There is evidence that uncertainty may encourage research and development in this regard (Bloom 2014). For instance, the study of Bar-Ilan and Strange (1996) is known as the first study finding out that when there is a long delay for an investment to be completed, uncertainty may have an accelerator effect on investment; in other words, an effect that promotes investment. Also, He et al. (2020) show that economic policy uncertainty generally positively affects corporate innovation.

There is comprehensive literature dating back to the 1980s in economy and finance on venture capital and corporations. This literature has highlighted the importance of financial market development, tax systems, labor market regulations, and public expenditures on research and development (Lerner and Tåg 2013). However, there is a limited number of studies researching the overall impact of macroeconomic policies on venture capital (Bonini and Alkan 2012; Huang, Wu, and Guo 2022; Kim and Paik 2022; Litov et al. 2021; Litterscheidt 2021; Tian and Ye 2018; Yi et al. 2022). Although the question of how uncertainty affects venture capital investment, the present literature has focused on the uncertainty of the project with a micro perspective. The first contribution of the study is demonstrating how venture capital reacts to economic policy uncertainty and filling this gap in the literature. To the best of our knowledge, this study is the first to approach this subject in terms of macro. Also, besides cointegration analysis which allows soft transitions to studying long-term relations between series, up-to-date methods that consider the effects of cross-section dependence and common factors are used. On the other hand, it is not possible to obtain beneficial results with the time-series methods due to the limited data set and annual data availability. Another contribution of the study is obtaining country-based results using up-to-date panel data methods despite the limited data availability. One of the reasons for choosing OECD countries is the characteristics of the countries. Firstly, the countries in this group consist of developed countries as well as countries leading innovation activities. Secondly, On the other hand, these are the countries that also include the G7 (Canada, France, Germany, Italy, Japan, UK and USA). Thirdly, OECD countries are important in that they represent about two-thirds of global net wealth and about half of world production (Christou and Gupta 2020).

OECD countries consist of countries that are financially developed, have stable economic policies and have higher economic growth rates. Therefore, economic policy uncertainty is relatively low in these countries. OECD economies consist of countries that contribute greatly to global income, financial development, high globalization and industrialization in the world (Dogan and Seker 2016; Ullah et al. 2022).

In OECD countries governments are among the main venture capital investors. For instance, in e.g., Korea and Canada, up to 50% of VC-backed start-ups receive some form of government (Brander, Du, and Hellman 2015). OECD has more than 90% of world venture capital. Thus, policy uncertainty is important for venture capital. OECD countries and Key Partners have about 80% of world trade and investment. On the other hand, as members of OECD countries, USA has the most ventures and Israel, United Kingdom,

India, Canada are the largest contributors. Venture capital investments in Europe amounted to USD 4.7 billion. In 2016, venture capital investments in the United States amounted to USD 66.6 billion. This value accounts for 86% of total venture capital investments in the OECD. Also, the U.S. accounts for 70–80% of global VC investments across all technologies (Breschi, Lassébie, and Menon 2018).

In this context, our study is important in terms of enriching both the risk capital and economic policy uncertainty literature. While the studies in the literature deal with the impact of economic policy uncertainty on venture capital investments from a micro perspective, they have barely addressed the macro perspective. The EPU has two important characteristics it can be both a loss and an important opportunity for venture capital investments. Therefore, the result obtained in this study on the positive effect of economic policy uncertainty on venture capital investments in the context of OECD countries can provide a new roadmap for further studies.

The study consists of three parts. The literature review is presented in the second part. Econometric methodology and empirical results are presented in the third part. The results are discussed in the last part, and a policy proposal is suggested.

2. The relationship between risk capital and economic policy uncertainty

Venture capital is a particular form of business finance designed to meet the needs of developing firms in technology sectors following significant growth potentials (Mason 2020). In other words, venture capital is generally provided to private businesses aiming to accelerate the development of a company through access to capital and a wide variety of business support services. While venture capital is generally regarded as a subset of private capital, it is associated with the investments made in the foundation phase of a business (Klonowski 2010). Venture capital (VC) contributes to start-ups with high growth potential by managing innovative activities that contribute to national wealth (Pradhan et al. 2017). Venture capital has two sides, supply and demand. On the demand side of venture capital, there is a financing alternative for entrepreneurs with innovative projects with high growth potential and high uncertainty. On the supply side, there are banks, pension funds, insurance companies, academic institutions, institutional investors, government agencies and private investors, and institutions providing venture capital (Félix, Nunes, and Pires 2023).

Capital formation starts with the private market, which is essential in allocating economic policy resources and investigating its effect on investments. Furthermore, venture capital (VC), a critical component of the private market, is demonstrated as an essential driving force of entrepreneurship, technological innovation, and economic growth (Tian and Ye 2018).

An active venture capital market has an accelerator effect on economic growth. Innovation led by young entrepreneur companies directs economic growth. However, the finance of relevant companies may be challenging due to moral hazards and asymmetric information (Lerner and Tåg 2013). The venture capital process has developed important mechanisms to overcome potential conflicts of interest in every stage of the investment process. In this regard, venture capital plays a vital role in minimizing the significant risks in the investment process, such as moral hazards and asymmetric information (Gompers 2007; Mason 2020).

Venture capital is vital in economic development regarding innovation, employment, R&D expenditures, and export sales. Moreover, this phenomenal growth rate is sustained in the long term. Venture capital-supported companies are quicker in product development and putting them on the market. Relevant companies pursue a more radical product or process innovation and produce more precious patents. Venture capital, therefore, is regarded as one of the main components of thriving entrepreneurship ecosystems. Also, countries, as a way of encouraging economic growth in regions lagging economically, create a more active public policy area by promoting venture capital funds (Mason 2020).

In recent years, there has been an increase in steps to promote entrepreneurship to support growth and employment creation worldwide. Some of these efforts are through direct participation in venture capital programs. The others are provided through indirect efforts aiming to create a corporate environment. These activities create an active venture capital market (Lerner & Tag, 2013). Venture capital is known to lead to company formation, technological innovation, employment, and economic growth (Gompers and Lerner 2004; Kortum and Lerner 2001). However, generally, various uncertainties accompany the benefits of venture capital. The economic uncertainty mentioned is a significant source of risk due to high uncertainty toward the survival and growth of supported portfolio companies (Huang, Wu, and Guo 2022).

Policy uncertainty states a situation where an economic unit cannot concisely predict whether the government will change the economic policies and when and how they will change (Kim and Paik 2022). In other words, uncertainty is described as a concept reflecting the possibilities about the future in the minds of executives, households, and policymakers (Bloom 2014). Policy uncertainty may result from budget determination decisions of government, political changes, or changes in regulations regarding taxes and investment. Frequent changes or indetermination in government policies make the work environment of a company complex, variable, and hard to predict. Consequently, these uncertainties significantly affect various investment decisions, including VC investment strategies (Kim and Paik 2022).

Costs of economic and political shocks are known to affect sales and profits significantly. Therefore, the shocks are an essential source of uncertainty for companies. In addition, economic policy changes affect the environment where companies are in service and, thus, the investment behaviors. Hence, policy uncertainty is closely related to unexpected changes that may alter the economic environment (Wang, Chen, and Huang 2014).

Finance and uncertainties about money and other regulatory policies in the USA and Europe resulted in a financial and economic recession in 2008. However, there has been a slow recovery period after the 2008 global crisis. Problems such as increasing unemployment, income inequality, and fluctuation in oil prices in that period made the global economies even more complicated. Also, policy uncertainties, as economic growth has been slowing down recently in most countries going through policy uncertainties shows, have played a significant role in shaping the economic consequences (Al-Thaqeb and Algharabali 2019). Since the 2008 crisis, there has been a growing body of literature focused on investigating the effects of uncertainty on the real economy (Tiwari, Nasir, and Shahbaz 2021).

3. Literature review

When the literature is reviewed, it focuses on the relationship between policy uncertainty and investment. A significant number of studies focus on the impacts of policy uncertainty on the real economy. Generally, the results of the studies focusing on the relationship between policy uncertainty and investment show that companies tend to reduce their investments in high uncertainty times (Baker, Bloom, and Davis 2016; Chen, Lee, and Zeng 2019; Dejuan-Bitria and Ghirelli 2021; Gulen and Ion 2016). However, former studies largely ignore the effects of VC investments on policy uncertainty and macroeconomic factors while focusing on the relationship between uncertainty and investment. Recent studies focus on the relationship between policy uncertainty and VC investments, yet it is seen that there still needs to be more studies about it. Whereas the results of the studies on policy uncertainty and VC investment show that high uncertainty times adversely affect VC investments (Bonini and Alkan 2012; Tian and Ye 2018, Litov et al. 2021; Litterscheidt 2021; Huang, Wu, and Guo 2022), there are studies demonstrating that EPU has good news effect (Kim and Paik 2022; Yi et al. 2022). In the current literature, studies on how venture capital investments respond to economic policy uncertainty have been discussed with micro approaches. In this context, our study is known as the first study that deals with the relationship between economic policy uncertainty and risk capital with a macro approach and in the context of OECD countries. As a result, our study can play an important role in closing this gap in the literature. In addition, the study differs from other studies in terms of obtaining strong country-based results by using current panel data techniques.

Tiwari et al. (2021) examined the synchronization of economic activity, financial stress, and uncertainty in the USA with the help of a wavelet-based adaptation approach. The results of the analysis show that policy uncertainty, financial stress, and joint movements of economic activity are time-dependent. In other words, it has been determined that financial stress plays an important role in the relationship between uncertainty and economic activity. Ullah et al. (2022) examined the effects of financial inclusion, economic policy uncertainty, and globalization on environmental quality by dividing 33 OECD economies into two groups according to their level of globalization: low globalized economies (LGE) and highly globalized economies (HGE). The analysis period covers the years 1996–2016 and the AMG (Augmented Mean Group) method was preferred. According to the findings, it was determined that financial inclusion had a negative effect on CO2 emissions in both groups. On the other hand, it was determined that economic policy uncertainty had a positive effect on both groups. Tang et al. (2023) analyzed the asymmetric effects of (US-EPU), Geopolitical Threats (GPRT), Geopolitical Laws (GPRA), and (WTI) crude oil on green bond yields for the USA between 2012–2022 using the NARDL model. According to the findings, it has been determined that the green bond yield in the short term is negatively affected by the increase in USEPU and GPRA. In addition, it was determined that the green bond yield was positively affected by the increase in GPRT and WTI. On the other hand, in the long run, the green bond yield is negatively affected by the increase in USEPU, GPRA, and GPRT. Finally, it is concluded that the long-term green bond yield is positively affected by WTI. Zhang et al. (2023) examined the relationship between geopolitical risk and green finance for Europe for the period 1 March 2012–16 February 2022 with the help of time-varying causality analysis. According to the findings, a time-varying Granger causality has been found from geopolitical risk to green finance.

3.1. Policy uncertainty and investment relationship

When we consider the relationship between policy uncertainty and investment in the context of growth theory, it is seen that uncertainty affects investments positively. For example; Tajaddini and Gholipour (2021) examined the relationship between economic policy uncertainty (EPU), per capita research and development (R&D) expenditures, and innovation outputs for 19 countries (Australia, Brazil, Canada, Chile, China, France, Germany, India, Ireland, Italy, Japan, the Netherlands, Russia, Singapore, South Korea, Spain, Sweden, the United Kingdom and the United Kingdom) were examined for the period between 1996 and 2015. According to the findings, higher EPU levels were found to be positively associated with innovation outputs as well as R&D expenditures per capita. He et al. (2020) examined the impact of economic policy uncertainty (EPU) on corporate innovation in China for the period covering 2000–2017. The findings show that, in general, EPU is positively related to corporate innovation investments. Shen et al. (2020) investigated the impact of economic policy uncertainty on corporate innovation in the period covering 2007–2017. According to the findings, it has been determined that economic policy uncertainty is positively related to corporate innovation. Guan et al. (2021) examined the impact of economic policy uncertainty on corporate innovation in China in the period covering 2001 to 2019. The results show that EPU is generally positively related to corporate technological innovation and negatively related to corporate business model innovation.

On the other hand, many studies are showing that economic policy uncertainty negatively affects investments. For example; Aizenman and Marion (1993) studied the relationship between policy uncertainty and growth for 46 developing countries between 1970–1985. According to the obtained results, it is ascertained that policy uncertainty negatively affects investment and growth. Servén (1998) studied the effect of macroeconomic uncertainty on investment in 94 developing countries from 1970–1995. According to the findings obtained, it is ascertained that macroeconomic uncertainty adversely and directly affects investment. Also, the adverse investment effect of uncertainty has a more significant impact on countries with less developed financial systems. Asteriou and Price (2005) studied the relationship between uncertainty, investment, and economic growth for the industrialised and developing 59 countries between 1966–1992. According to the findings, it is concluded that uncertainty creates an effect reducing both investment and growth. Fatima and Waheed (2011) analyzed the impacts of macroeconomic uncertainty on investment and economic growth in Pakistan through the GARCH model between 1975–2008. The analysis shows that macroeconomic uncertainty adversely impacts investment and per capita income. Julio and Yook (2012) studied how political uncertainty affected institutional investments by examining 248 national election data from 48 countries between 1980–2005. According to the findings, it is determined that political uncertainty leads companies to reduce their investment spending until the election uncertainty is solved. Wang et al. (2014) analyzed how policy uncertainty affected the institutional investments of Chinese companies between 2003–2012. According to the analysis results, it is determined that companies tend to reduce their investments when the policy uncertainty rate is high. Kang et al. (2014) investigated the impact of economic policy uncertainty and its components on investment with the help of an error correction model for more than 2700 US manufacturing firms between 1985 and 2010. According to

the findings, it was found that economic policy uncertainty suppresses the investment decisions of firms. It is also concluded that the news-based policy shock has a long-term negative impact on investments.

Baker et al. (2016) studied the relationship between policy uncertainty and share price volatility at the company level, investment rates, and employment increase with the help of VAR analysis for the most significant 12 economies. The results emphasize the adverse economic impacts of uncertainty shocks. Gulen and Ion (2016) discussed the relationship between policy uncertainty and capital investment at the company level between the years 1987:1–2013:12. According to the findings obtained, it is determined that there is a strong negative relationship between capital investment at the company level and total uncertainty level. Chen et al. (2019) analyzed the relationship between investment and uncertainty for 175 companies in the USA market between 1999–2013. The results show that companies reduce their investments when faced with higher economic policy uncertainties. Guo et al. (2020) examined the effect of EPU on corporate investment and profitability for China in the period 2003Q1-2018Q3 with the help of the PVAR model. The results show that the EPU has a negative effect on the investment and profitability of the firms. Dejuan-Bitria and Ghirelli (2021) studied the impact of economic policy uncertainty on the investment decisions of companies in Spain between 1998–2014. According to the analysis results, strong evidence is obtained that uncertainty decreases institutional investment. Cui et al. (2021) examined the impact of economic policy uncertainty on institutional innovation investment in China over the period 2007–2017. Analysis results show that EPU negatively affects corporate innovation investment. Finally, Kong et al. (2022) examined the impact of the EPU on the investment decisions of firms in China over the period 2007–2019. According to the findings, it was determined that the EPU prevented the increase in the investment scale and productivity of the firms.

3.2. Policy uncertainty and venture capital investments

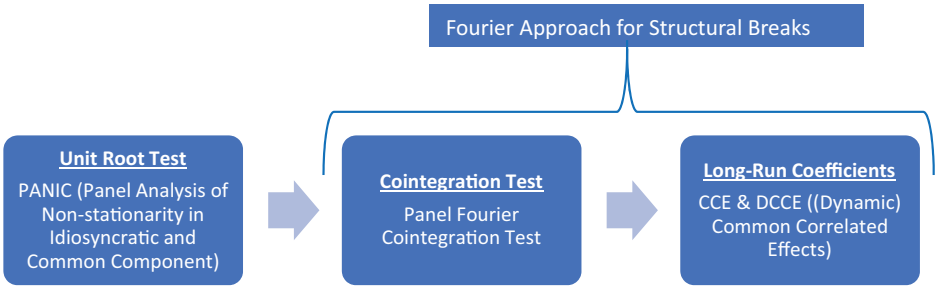
Bonini and Alkan (2012) studied how economic uncertainty affected venture capital investments in 16 countries between 1995–2002. According to the findings obtained, it was concluded that low political uncertainty triggers higher venture capital investments. Tian and Ye (2018) analyzed the effect of economic uncertainty on venture capital by using 30,408 entrepreneurial company examples in China between 1987–2015. According to the findings, a negative relationship was found between economic uncertainty and venture capital propensity to invest. Litov et al. (2021) studied the impact of policy uncertainty on venture capital Investments between 1987–2015 by using the data obtained from entrepreneurial companies from 22 countries. Empirical results show that policy uncertainty negatively affects venture capital investments. Finally, Litterscheidt (2021) studies the impact of economic uncertainty on the finance and success probability of start-up companies in the venture capital market between 1998–2015 for 13,680 Europe start-up companies. According to the findings obtained, it is stated that the possibility of venture capital investors joining financing activities is lower when there is economic uncertainty. On the other hand, it is concluded that start-up companies have a lower possibility of starting up successfully under high economic policy uncertainty. Huang et al. (2022) analyzed how economic policy uncertainty affected their decisions and starting-up results in investment stages in

China's venture capital (VC) market in the period between 2000–2018. According to the findings obtained, it was concluded that venture capital delays refinance companies under high economic uncertainty. In other words, there is evidence obtained that investments made in high economic uncertainty times are less likely to start up successfully.

Hypothesis 1. *Economic policy uncertainty negatively affects venture capital investments.*

Kim and Paik (2022) analyzed the relationship between policy uncertainty and venture capital by using data on the corporate venture capital (CVC) investments made by publicly held corporations in the USA until the period between 1997–2000. According to the findings obtained, it was stated that policy uncertainty is positively correlated with the number of funds allocated to CVC investment. Yi et al. (2022) studied the relationship between VC corporations with policy uncertainty in China between 1997–2019. According to the findings, China's economic policy uncertainty (EPU) creates a good news effect. In other words, it is deduced that EPU may increase the investment amounts of venture capital corporations Graphic 1.

Hypothesis 2. *Economic policy uncertainty positively affects venture capital investments.*



Graphic 1. Graphical summary for methodology.

The summary of the literature review shows the studies that have addressed the relationship between economic policy uncertainty and venture capital investment. Panel data techniques were used in the studies due to limited data availability for all studies. In addition, the studies are focused on the relationship between economic policy uncertainty and venture capital investment, taking on a firm basis. However, as seen in the literature, this relationship has been addressed by a limited number of studies. For this reason, it is seen that it is an important discipline that needs to be emphasized. Our study plans to fill this gap in the literature with the help of a macro approach to enrich the existing knowledge.

In this study, the hypotheses were examined in the context of two hypotheses: economic policy uncertainty negatively affects venture capital investments and economic policy uncertainty positively affects venture capital investments. It was previously explained why OECD countries were preferred within the scope of the study. Therefore,

it is important to examine the impact of economic policy uncertainty on venture capital investments in the context of OECD countries.

4. Data & methodology

In this study, the effects of financial uncertainty on venture capital investments for 14 OECD countries (Australia, Canada, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, Spain, Sweden, United Kingdom, and the United States) in the years between 2007–2020 are discussed.

Venture capital is a form of equity financing particularly relevant for young companies with innovation and growth potential but untested business models and no track record. It replaces or complements traditional bank finance. The development of the venture capital industry is considered a vital framework to stimulate innovative entrepreneurship. Aggregate data on venture capital provide helpful information on trends in the venture capital industry. These data are typically compiled by national or regional Private Equity and Venture Capital Associations, often with the support of commercial data providers.

Venture capital is made up of the sum of early stage (including pre-seed, seed, start-up, and other early stage) and later stage venture capital in the OECD Entrepreneurship Financing Database. Venture capital investment figures should be paid attention to in two aspects of international comparisons. First, there is no standard international exact description of venture capital. Besides, there is no general acceptance. The description of investment types incorporated in venture capital may vary between countries and regions. On the other hand, different methodologies may be used by data compilers. However, collective venture capital data quality and availability have recently improved considerably (OECD Database, 2022).

Each national EPU index reflects the relative frequency of own-country newspaper articles that contain a trio of terms on the economy (E), policy (P), and uncertainty (U). In other words, each monthly national EPU index value is proportional to the share of own-country newspaper articles that discuss economic policy uncertainty that month (for detailed information, see the article, by Baker, Bloom, and Davis 2016). In addition, the combination of some studies provides an economic policy uncertainty index. These studies may be examined for detailed information; Baker, Bloom, and Davis (2016) (Australia, Brazil, Canada, France, Germany, Italy, South Korea, United Kingdom, United States); Hardouvelis et al. (2018) (Greece); Zalla (2016) (Ireland); Arbatli et al. (2019) (Japan); Kroese, Kok and Parlevliet (2015) (Netherlands); Ghirelli, Perez, and Urtasun (2019) (Spain) and Armelius, Hull, and Köhler (2017) (Sweden).

Table 1 shows descriptive statistics and cross-sectional dependency test results for Venture Capital Investment (VC) and Economic Policy Uncertainty Index (EPU).

In Table 1, the average of VC and EPU are 5782.4 and 158.94, respectively. The minimum and maximum values of VC and EPU are 6.6–137856.9 and 41.9–468.7,

Table 1. Descriptive statistics & CD test results.

Variables	Obs	Mean	Std. Dev.	Min	Max	CD Test	Prob.
VC	196	5782.4	20789.6	6.629	137856.9	20.34	0.000
EPU	196	158.94	81.672	41.967	468.747	12.04	0.000

respectively. Thus, the natural logarithms of both variables are used. On the other hand, according to the CD test results used to investigate the cross-sectional dependence, the basic hypothesis suggesting that there is no cross-sectional dependence is rejected. As a result, it is decided that there is a cross-section dependence in the series Graphic 2.

Authors	Time	Country	Findings
Tian and Ye (2018)	1987-2015	China	(-)
Litov et al. (2021)	1987-2015	22 Countries	(-)
Litterscheidt (2021)	1998Q-2015Q1	Europe	(-)
Huang et al. (2022)	2000-2018	China	(-)
Kim and Paik (2022)	1997-2020	USA	(+)
Yi et al. (2022)	1997-2019	China	(+)

Graphic 2. Graphical summary for EPU-VC relationships.

Due to the existence of cross-section dependency, second-generation unit root tests should be used. Second-generation unit root tests consider cross-sectional dependence.

One of the Second-generation unit root tests, the PANIC (Panel Analysis of Non-stationarity in Idiosyncratic and Common Component) test, proposed by Bai and Ng (2004) allows analysis of not only the observed variables but also the stationarity of hidden time-varying common factors (Erdoğan et al. 2020).

Bai and Ng (2004) propose decomposing Y_{it} into three components.

$$Y_{it} = D_{it,p} + \lambda_i^{'} Ft + e_{it} \quad (1)$$

Here, D_{it} represents the polynomial trend function, Ft: Ft = [F1t, F2t, . . ., Frt]′ is a r × 1vector of common factors, and λi = [λ_1,λ_2, . . ., λ_r]′ is a vector of factor loadings. In this case, Y_{it} consists of a deterministic component (D_{it}), common factors ($F_{it,}$) and an idiosyncratic component (e_{it}). In Equation 1, if $p = 0$ the model is the intercept model and if $p = 1$, the model is the intercept and trend model. With this decomposition, not only is the stationarity analysis performed, but also whether the stationarity stems from the common factor or idiosyncratic component or both can be investigated. Unobserved dynamic common factors are extracted from each cross-section according to the principal components method (Erdoğan et al. 2020). In the Cross-sectional Average (CA) method, the

common factors and idiosyncratic terms are assumed to be equally stationary. In the PANIC test, not only the common factors but also the stability of the idiosyncratic component (eit) can be examined. The unit root tests may tend to reject the null hypothesis, especially when one of the components is strongly I (0) and the other is I (1). This problem is eliminated with the PANIC test. In addition, since the components are separated in the PANIC test, the degree of cross-sectional dependency of idiosyncratic components decreases. Finally, since more cross-sectional information can be used in the PANIC test, the estimation results are more reliable (Demircan Çakar et al. 2021). If at least one common factor of the Ft vector is not stationary and/or its idiosyncratic eit term is not stationary, then Y_{it} is decided not to be stationary.

There are three test statistics proposed for the unit root test of e_{it} each for $p = 0$ and $p = 1$ and are denoted as $P_{a,p}$, $P_{b,p}$ and $PMSB_p$ [Panel Modified Sargan – Bhargava] tests.

For $p = 0$

$$P_{a,p=0} = \frac{\sqrt{NT}\left(\hat{\rho}_0^+ - 1\right)}{\sqrt{2\hat{\phi}_\varepsilon^4\hat{\omega}_\varepsilon^4}} \text{ and } P_{b,p=0} = \frac{\sqrt{NT}\left(\hat{\rho}_0^+ - 1\right)}{\sqrt{\hat{\phi}_\varepsilon^4 / \left[\hat{\omega}_3 N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^0\right)'\hat{e}_{i,-1}^0\right]}} \tag{2}$$

$$PMSB_{p=0} = \frac{\sqrt{N}\left(N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^0\right)'\hat{e}_{i,-1}^0 - \hat{\omega}_\varepsilon^2/2\right)}{\sqrt{\hat{\phi}_\varepsilon^4/3}} \tag{3}$$

For $p = 1$

$$P_{a,p=1} = \frac{\sqrt{NT}(\hat{\rho}_1^+ - 1)}{\sqrt{36\hat{\sigma}_\varepsilon^4\hat{\phi}_\varepsilon^4/5\hat{\omega}_\varepsilon^8}} \text{and } P_{b,p=1} = \frac{\sqrt{NT}(\hat{\rho}_1^+ - 1)}{\sqrt{6\hat{\sigma}_\varepsilon^4\hat{\phi}_\varepsilon^4 / \left[5\hat{\omega}_\varepsilon^6 N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^0\right)'e_{i,-1}^0\right]}} \tag{4}$$

$$PMSB_{p=1} = \frac{\sqrt{N}\left(N^{-1}T^{-2}\sum_{i=1}^{N}\left(\hat{e}_{i,-1}^0\right)'\hat{e}_{i,-1}^0 - \hat{\omega}_\varepsilon^2/6\right)}{\sqrt{\hat{\phi}_\varepsilon^4/45}} \tag{5}$$

In the PANIC test, the null hypothesis represents unit root and the alternative hypothesis stationarity. PANIC test statistics are as follows: P_a and P_b are PANIC test statistics. PMSB shows the corrected Sargan Bhargava test statistics in case of autocorrelation. In Table 2, PANIC unit root test results can be seen.

According to the intercept model results and the intercept & trend model results in Table 2, LNVC, the null hypothesis cannot be rejected at the 5% significance level, and it is decided that the series is not stationary. On the other hand, according to the intercept model results for LNEPU, for P_a and P_b, the null hypothesis can be rejected at the 5% significance level, and according to the intercept and trend model results for P_a null hypothesis can be rejected at the 5% significance level and for P_b null hypothesis cannot be rejected at the 5% significance level. Also, according to the PMSB (the corrected Sargan Bhargava test statistics in case of autocorrelation) test results, for P_a and P_b, the null hypothesis

Table 2. PANIC unit root test results.

	LNVC				LNEPU			
	Intercept		Intercept &Trend		Intercept		Intercept &Trend	
Tests	Stat.	*p*-value	Stat.	*p*-value	Stat.	*p*-value	Stat.	*p*-value
Pa	−1.055	0.146	−1.268	0.102	−2.890	0.002	−1.782	0.037
Pb	−0.810	0.209	−1.127	0.130	−1.914	0.028	−1.497	0.067
PMSB	−0.880	0.190	−0.758	0.224	−1.187	0.118	−0.893	0.186

can be rejected at the 5% significance level. Considering that the series are in the trend effect, the results of the intercept and trend model will give more accurate results. Therefore, it is decided that both series are not stationary.

After investigating the stationarity of the series, long-run relationships can be discussed. To be able to do this, Westerlund error-correction-based panel cointegration tests, which also take into account the cross-sectional dependency, are preferred. However, according to the test results, it was seen that there was no long-term relationship between the series. The results can be seen in Appendix 1. However, possible structural breaks in the cointegrated relationships between the series may lead to biased results in order not to reject the null hypothesis.

For this reason, a cointegration estimation model, which also takes into account structural breaks and cross-sectional dependence, is preferred in our study. This panel cointegration test is robust to nonlinearity, unknown numbers, and forms of structural breaks and cross-sectional dependency.

Representing structural breaks with dummy variables can lead to using the wrong specification. On the other hand, if the number and form of the breaks are unknown, the Fourier form is a reasonable estimation method, which allows the modeling of smooth transition (Enders and Lee 2009). The cointegration estimation model is shown in Equation 6.

$$LNVC_{it} = \beta_{0i} + \beta_{1i} LNEPU_{it} + v_{it} \tag{6}$$

$$v_{it} = \rho_i v_{it-1} + \varepsilon_{it}. \tag{7}$$

The estimation steps for the cointegration test are applied as follows. First, Equation.6 is estimated and error terms are obtained, $\hat{v}_{it}$. Equation 7 is then estimated using error terms and obtain $\hat{\rho}_i$ and $\left\{\hat{\phi}_{it}\right\}$ given by $\hat{\phi}_{it} = \hat{v}_{it} - \hat{\rho}_i \hat{v}_{it-1}$. Then compute the pseudo residuals $\left\{\ddot{\phi}_{it}\right\}$ by replacement from $\left\{\hat{\phi}_{it}\right\}$ using the residual-based stationarity bootstrap. Compute pseudo residual $\{\ddot{v}_{it}\}$ by cumulating $\left\{\ddot{\phi}_{it}\right\}$ for null hypothesis. Compute $L\ddot{N}VC_{it} = \hat{\beta}_{0i} + \hat{\beta}_{1i}\ L\ddot{N}EPU_{it} + \ddot{v}_{it}$ to obtain $L\ddot{N}VC_{it}$. Estimate Equation 6 using dataset $\left\{L\ddot{N}VCit, LNEPU_{it}\right\}$. Estimate $\ddot{\rho}_i$ using Equation 7 and $\left\{\ddot{v}_{it}\right\}$ from previous estimation. Finally, repeat the process (Olayeni et al. 2021).

This predictive model has been extended for nonlinearity and structural breaks. The model is extended with Fourier functions for structural breaks. Fourier Functions can be seen in Equation 8.

$$\tilde{v}_{it} = \hat{v}_{it} - \hat{\alpha}_{it} - \hat{x}_i sin\left(\frac{2\pi kt}{T}\right) - \widehat{\varphi}_i cos\left(\frac{2\pi kt}{T}\right) \tag{8}$$

In Equation 8, $\hat{x}_i$ and $\widehat{\varphi}_i$ are the estimated amplitude and displacement parameters. k is the approximation frequency. In the case of a nonlinearity problem, the KSS (Kapetanios, Shin, and Snell 2003) approach is used. k is estimated in Equation (9).

$$\hat{k} = argmin\ SSR(k) \tag{9}$$

$$k \in [0.1, 2]$$

Here SSR is the sum of squared residuals evaluated as k. In Table 3, panel Fourier cointegration test results can be seen.

In Table 3, for the first part, it can be seen the individual statistics for all countries. For the second part of Table 3, group statistics (panel statistics) can be seen. According to the results, except for Australia, Canada and Greece, the optimal frequency parameter is a fractional quantity for all other countries. Also, the individual statistics show that there is a long-run relationship between venture capital and uncertainty for all countries. On the other hand, group statistics support the individual results.

As a result, it has been observed that there is a long-term relationship between the series. The CCE (Common Correlated Effects) and DCCE (Dynamic Common Correlated Effects) methods are used to investigate the direction and magnitude of the relationships

Table 3. Panel Fourier cointegration test results.

	GLS					PP				
	Individual Statistics									
	Stat.	1%	5%	10%	k	Stat.	1%	5%	10%	k
Australia	−3.282	−3.158	−1.917	−0.011	1	−4.098	−3.191	−1.774	0.993	1
Canada	−3.278	−3.411	−2.102	−1.324	1	−4.56	−3.114	−1.979	−1.308	1
France	−3.02	−3.187	−1.501	−0.221	0.1	−2.871	−2.8	−1.289	1.771	0.1
Germany	−3.452	−3.185	−1.903	−0.633	0.6	−3.816	−2.625	−1.698	−0.67	0.6
Greece	−4.956	−3.953	−2.145	−0.305	1	−9.403	−4.462	−2.191	−0.921	1
Ireland	−4.054	−2.818	−1.798	0.02	0.1	−4.471	−3.004	−1.695	1.084	0.1
Italy	−6.705	−3.726	−2.262	0.095	2.9	−7.588	−3.968	−2.035	0.511	2.9
Japan	−3.239	−2.597	−1.601	0.283	2.3	−3.144	−2.562	−1.548	1.038	2.3
Korea	−3.349	−2.773	−1.743	0.036	0.1	−3.936	−2.757	−1.537	2.002	0.1
Netherlands	−2.36	−2.667	−1.677	−0.311	0.1	−2.318	−3.23	−1.296	1.438	0.1
Spain	−3.408	−2.994	−1.747	−0.468	1.1	−5.776	−2.641	−1.59	−0.541	1.1
Sweden	−3.835	−2.841	−1.85	0.185	2.4	−3.974	−3.081	−1.696	0.323	2.4
United Kingdom	−3.553	−3.311	−1.779	−0.138	0.1	−5.469	−2.972	−1.594	0.568	0.1
United States	−7.453	−4.087	−2.581	−1.189	2.8	−10.039	−4.329	−2.537	−1.165	2.8
Group Statistics										
	Mean	−3.996	(0.032)			**Mean**	−5.105	(0.025)		
	Max	−7.453	(0.000)			**Max**	−10.039	(0.001)		
	Median	−3.452	(0.069)			**Median**	−4.471	(0.033)		

In group statistics, the *p*-values are reported in parentheses. Both the *p*-values and the critical values are based on the 1000 drawings.

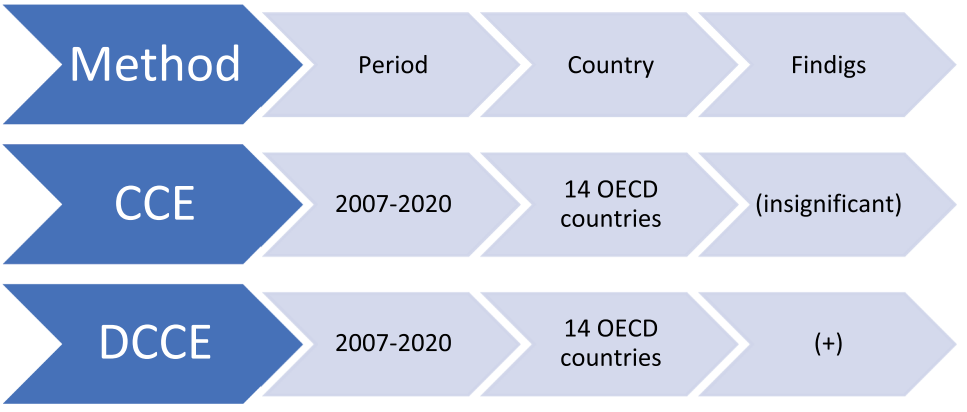
Table 4. CCE & DCCE test results.

	CCE Test Results			Dynamic CCE Test Results		
Countries	Coeff.	Std.Err.	Prob.	Coeff.	Std.Err.	Prob.
Australia	0.757	0.601	0.208	0.795	0.330	0.016
Canada	0.137	0.730	.852	1.545	0.083	0.000
France	0.078	0.171	0.646	0.575	0.084	0.000
Germany	0.086	0.196	.660	0.390	0.036	.000
Greece	0.215	0.616	0.727	−0.827	0.373	0.026
Ireland	0.307	0.194	0.113	0.520	0.014	0.000
Italy	1.540	0.954	0.106	1.053	0.097	0.000
Japan	−1.653	0.951	0.082	0.485	0.307	0.114
Korea	0.428	0.308	0.165	0.217	0.132	0.100
Netherlands	0.504	0.280	0.072	0.195	0.058	0.001
Spain	−0.119	0.518	.0819	0.811	0.058	0.000
Sweden	−1.245	0.946	0.188	0.874	0.359	0.015
United Kingdom	0.427	0.203	0.035	0.313	0.024	0.000
United States	−2.010	0.891	0.024	−0.426	0.294	0.147
Group Estimation						
	CCE Test Results			Dynamic CCE Test Results		
	Coeff.	Std.Err.	Prob.	Coeff.	Std.Err.	Prob.
	−0.039	0.257	0.879	0.466	0.158	0.003

between the series. In this way, long-term coefficients can be obtained and the relationships between the series can be interpreted.

The CCE proposed by Pesaran (2006) and DCCE proposed by Chudik and Pesaran (2015) methods are shown to be robust to different types of cross-section dependence of errors, possible unit roots in factors, and slope heterogeneity. Also, CCE estimator is to eliminate asymptotically the differential effects of unobserved common factors by cross-sectional averages. Chudik and Pesaran (2015) stated that the CCE estimator is inconsistent for dynamic panels. Because CCE estimator is not robust the idiosyncratic errors are cross-sectionally weakly dependent and the lagged dependent variable is no longer strictly exogenous. Thus, Chudik and Pesaran (2015) propose a dynamic common correlated effects methodology. For DCCE estimator, the cross-sectional averages of the variables are added to the model to represent the unobservable factors. Thus, the heterogeneous effects of global shocks are eliminated. In this study, CCE and DCCE methodologies are used for their advantages. In Table 4, CCE and DCCE test results can be seen.

In Table 4, according to individual results for CCE model, except Japan and Netherlands, economic policy uncertainty does not affect the venture capital. Also, the group results support the individual results. In Table 4, according to DCCE model results, except in Japan, Korea, and the USA, economic policy uncertainty affects venture capital. In other words, for most countries, economic policy uncertainty is an important determinator for venture capital. Also, the group results support the individual results. According to the group result, economic policy uncertainty affects venture capital positively. According to individual results for DCCE model, except in Greece, economic policy uncertainty affects venture capital positively. Finally, our results support the hypothesis that "Economic policy uncertainty positively affects venture capital investments" Graphic 3.



Graphic 3. Graphical summary for findings.

5. Conclusion

It is known that the economic performance of countries is based mainly on science and technological advances at present. Therefore, innovation expressed as the reason for technological advances considerably contributes to the countries' sustainable growth performance. Recently, venture capital investments, described as the driving force of innovation, generally emerge as investments made to high technology products and contribute to production with high added value and more valuable patterns as they include high risks. Therefore, besides having some characteristics such as high risk, unpredictability, and uniqueness, venture capital plays a significant role in the sustainability of economic growth in the long term.

This study focused on economic policy uncertainty which is a significant factor mainly affecting investments. Economic policy uncertainty is regarded as an undefined risk in the short term, causing variations in the economic units' predictions regarding the future. Economic policy uncertainty may lead to two positive and negative consequences on macroeconomic performance. Economic units may resort to delaying their investment and spending decisions due to uncertainty in the market, which may adversely affect macroeconomic performance. On the other hand, economic units may choose to wait for the most appropriate investment opportunity due to uncertainty in the market. The investment income of economic units may increase because of the relevant election. Therefore, the relationship between venture capital investments accepted as a type of private market and economic policy uncertainty has been analyzed at the macro level in this study due to these two consequences that economic policy uncertainty causes on investments. The results have demonstrated that economic policy uncertainty significantly affects venture capital investments.

In this study, the effects of economic uncertainty on venture capital for 14 OECD countries (Australia, Canada, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, Spain, Sweden, United Kingdom, and the United States) between 2007 and 2020 years are investigated. In this study, aims to reveal the effect of economic policy uncertainty on venture capital investment in the context of OECD countries. Therefore, the effect of economic policy uncertainty on venture capital investments under different

conditions constitutes the main research question of this study. In the literature, there is no study that deals with the effects of economic policy uncertainty on venture capital at a macro level. To the best of our knowledge, this is the first study that deals with the effects of economic policy uncertainty on venture capital investments with a macro approach. Due to the significant effects of policy uncertainty on the real economy, studies are needed to investigate the impact on venture capital. As a result, our study can play an important role in closing this gap in the literature and may guide future studies, given the limited scope of the study.

According to panel Fourier cointegration test results (FFFFF) for GLS and PP models, except for Australia, Canada, and Greece, the optimal frequency parameter is a fractional quantity for all other countries. Also, the individual statistics show a long-run relationship between venture capital and economic policy uncertainty. On the other hand, group statistics support individual results. As a result, it has been observed that there is a long-term relationship between the series.

The CCE (Common Correlated Effects) and DCCE (Dynamic Common Correlated Effects) methods are used to investigate the direction and magnitude of the relationships between the series for their advantages.

According to individual and group test results for the CCE model, except in Japan and the Netherlands, economic policy uncertainty does not affect venture capital. According to DCCE model results, except in Japan, Korea, and the USA, economic policy uncertainty affects venture capital. In other words, for most countries, economic policy uncertainty is an important determinator of venture capital. Also, the group result supports the individual results. According to the group result, economic policy uncertainty affects venture capital positively. According to individual results for the DCCE model, except in Greece, economic policy uncertainty affects venture capital positively. As a result, it has been observed that the increase in economic uncertainty in the long term increases venture capital investments in developed countries.

The climate crisis causes serious uncertainty in firm sizes and economic policy strategies. Recently, EU practices such as environmental taxes (carbon application at the border) have increased costs and lead to changes in existing economic relations. New applications for emission trading within approaches such as circular economy in OECD countries dramatically affect the investment ecosystem. Therefore, when considered in the context of growth theory, the uncertainty caused by the climate crisis can have a positive impact on investments. In this context, both monetary policy and fiscal policy uncertainty have a significant impact on investments such as risk capital, a special type of financing caused by climate change.

Finally, when the analysis results are examined, it is seen that economic policy uncertainty positively affects venture capital investments. It is seen that the second hypothesis discussed in this study is confirmed. On the other hand, our results also support the growth hypothesis, which suggests that economic policy uncertainty can positively affect investments. In this context, Kim and Paik (2022), Yi et al. (2022), and He et al. (2020), their results support our findings. Therefore, some policy suggestions have been included, considering the situation of the countries within the scope of the sample: Economic units under the economic policy uncertainty regarded as a leading indicator may provide optimization and productivity in the market by acting more cautious in the decisions they will make. When

businesses face economic uncertainty, they may develop a competitive advantage and keep up with the changes regarding future predictions, resorting to developing their own capacities. For the countries within the scope of the sample, it is foreseen that economic policy uncertainty will lead businesses to increase their investments. Therefore, it is crucial for policymakers to follow policy uncertainty periodically. Finally, a significant impact on environmental quality can be created by increasing the share of green innovation practices aimed at reducing carbon emissions in risk capital.

The limitations of this study can be expressed as follows. Time-varying analyzes can be made with much more countries and observations. In this way, country-based policy changes can be examined. However, the inability to make country-based analyses with limited annual data is an important limitation of the study. On the other hand, as data and observations increase, it will be possible to conduct country-based analyses with more explanatory variables.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix 1: Westerlund ECM panel cointegration tests

Statistics	Values	Z-value	*P*-value	Robust *P*-value
Gt	−2.120	1.135	0.872	0.470
Ga	−3.663	4.594	1.000	0.210
Pt	−5.077	3.232	0.999	0.590
Pa	−3.172	3.515	1.000	0.310