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Determinants of Venture Capital Investment in Europe: Evidence from Innovation-System Indicators (2013–2020)

Abstract

This paper examines country-level determinants of venture capital investment (VCI) across 22 European economies from 2013 to 2020. We combine Invest Europe VCI totals with 14 indicators from the Global Innovation Index (GII) and classify each indicator into quintile tiers. Using one-way ANOVA with Tukey HSD post-hoc tests, we assess whether VCI differs systematically across tiers for each determinant. VCI is highly concentrated: France and Germany form a persistent upper tail, followed by the Netherlands, while Romania, Bulgaria, and Greece sit at the lower end. Eleven of fourteen indicators display significant between-tier differences in VCI: business environment, government effectiveness, gross expenditure on R&D, human capital and research, ICT access, ICT use, knowledge & technology outputs, knowledge creation, patent applications, PCT applications, and university–industry collaboration. By contrast, creative goods & services, ICT services exports, and political/operational stability do not discriminate VCI within this European sample. Results are robust to alternative binning, log-VCI transformation, and exclusion of the largest ecosystems. We interpret the patterns as consistent with VCI concentrating where

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institutional quality is strong, innovation inputs are deep, digital readiness is advanced, and knowledge/IP outputs are abundant. The findings offer actionable priorities for policy aimed at strengthening SME finance ecosystems, while acknowledging the study's associative design and the aggregation of VCI across stages and sectors.

Keywords: venture capital, innovation, Global Innovation Index, Europe, R&D, digital readiness, NOVA

1. INTRODUCTION

According to the European Commission, small and medium-sized enterprises (SMEs) account for over 99% of businesses in the EU and provide jobs to more than 85 million people, placing them at the heart of Europe's innovation and entrepreneurship (European Commission, 2023; European Commission, n.d.). Because SMEs are key carriers of new products and processes, their competitiveness and contribution to growth depend critically on sustained innovation. In the context of globalisation, innovation is a main source of countries' competitiveness (Karahan, 2016). Consistent with this view, the European Central Bank (2017) notes that innovation raises productivity by enabling economies to produce more with fewer resources, and a recent McKinsey (2023) survey reports that 84% of participating CEOs view innovation as vital for company growth. The pursuit of innovation is therefore central to economic development and competitiveness worldwide (Chaparro-Banegas et al., 2023). However, financing conditions for innovative, intangible-intensive SMEs are hampered by information frictions and weak collateral, limiting access to bank credit (OECD, 2020; Ferrando & Pál, 2024).

Against this backdrop, venture capital investment (VCI) provides equity, expertise, and monitoring suited to high-uncertainty SME projects, serving as an important intermediary for technology-intensive firms and innovative activity. A wealth of evidence links VCI to innovation and growth (Margaryan & Terzyan, 2023; Wang et al., 2023; Khan et al., 2021; Pradhan et al., 2018; Karahan, 2016) and shows that it often fuels major economic expansion, especially in technology sectors (Pantea & Tkacik, 2024). VCI is thus recognized as a key investment (Margaryan & Terzyan, 2023; Marti & Puertas, 2023) that provides essential financial resources, typically in exchange for equity, allowing entrepreneurs to grow and scale their businesses (Pantea & Tkacik, 2024), particularly those start-ups with the highest growth and employment creation potential (Arnold, Claveres & Frie, 2024; De Haas, Sterk, & Van Horen, 2022). Together with research and experimental development (R&D), VCI is frequently associated with stronger SME-led innovation performance at the ecosystem level (Padgureckienė & Cibulskienė, 2024; Wang et al., 2023).

Despite the recognized importance of VCI for SMEs, the European landscape is marked by complexity and considerable heterogeneity across countries. The European Union (EU) overall has an underdeveloped VC industry that holds back productivity and growth, with VC investments averaging less than one-third of the US average over the last decade (Arnold, Claveres & Frie, 2024). The need to increase the supply of VC is motivated by this investment gap (Pantea & Tkacik, 2024; European Investment Bank, 2019; Duruflé et al., 2017; Quas et al., 2022). At the same time, the European evidence base on VCI is uneven. As reviewed by Pantea & Tkačik (2024), published studies disproportionately cover a handful of Western and Northern European countries (e.g., Italy, Spain, Belgium, France, the United Kingdom, Finland, Germany), with far fewer studies on smaller EU and Central and Eastern European (CEE) economies. This imbalance likely reflects the concentration of VC activity in Europe (Nepelski, Piroli & De Prato, 2016) and data availability; it also means that countries with thinner VC markets, where VC effects and determinants may differ (Bertoni, D'Adda & Grilli, 2016), are under-documented even though some have recently experienced rapid VCI growth (e.g., Estonia, Ireland).

Since the global financial crisis, access to finance for innovative SMEs has remained challenging: stricter lending standards, limited access to capital markets, and insufficient collateral have compounded financing frictions (Mrkaic & Öztürk, 2014). Limited awareness of financing options and high costs of adopting new technologies further hinder SME growth (Kafaji Mohammed, 2022). While alternative instruments may mitigate some constraints (Kraemer-Eis & Lang, 2012), understanding the determinants of VCI into SMEs remains central to improving innovation finance.

This substantial divergence in VCI utilisation across Europe, combined with the established link between VCI and national innovation capacity, motivates the present research. We address two questions: (1) What are the determinants of VCI in European countries? (2) What measures can developing countries adopt to increase VCI and support SMEs effectively? The second question speaks to policy transferability: identifying which innovation and institutional features correlate with higher VCI in Europe can inform reform priorities in developing economies.

Empirically, we examine the determinants of VCI across 22 European countries during 2013–2020. We combine country-level VCI from Invest Europe with 14 indicators from the Global Innovation Index (GII, Dutta, Lanvin, & Wunsch-Vincent, 2020), spanning innovation inputs (e.g., R&D intensity; human capital), institutional quality (e.g., government effectiveness; business environment), digital readiness (ICT access and use), and innovation outputs (e.g., patenting; knowledge & technology outputs). Methodologically, we group observations into GII-based tiers and employ one-way ANOVA to test how VCI levels differ across tiers, applying Tukey HSD for post-hoc comparisons and homogeneous subsets. We interpret these tier-based differences as evidence on determinants in the comparative, cross-country sense; we do not make causal claims. Previewing our results, higher VCI is associated with ICT access and use, R&D intensity (GERD), patent activity (including PCT applications), knowledge & technology outputs, university–industry collaboration, government effectiveness, and business-environment quality, whereas creative goods and services, ICT services exports, and broad measures of political/operational stability are not significant in this period.

The remainder of the paper is organised as follows. Section 2 reviews the literature and positions our contribution. Section 3 sets out the methods (data sources, variables, tier construction, hypotheses, and statistical tests). Section 4 presents and discusses the results, including country contrasts and determinant-specific ANOVAs with post-hoc comparisons, and links findings back to the hypotheses. Section 5 concludes with policy implications, study limitations, and directions for future research.

2. LITERATURE REVIEW

Venture capital investment (VCI) in Europe is shaped by the architecture of national innovation systems – how institutions, finance, talent, digital infrastructure, and knowledge creation interact to generate investable opportunities and scalable firms. Within this framework, we foreground Global Innovation Index (GII) indicators (Dutta, Lanvin, & Wunsch-Vincent, 2020) that map onto these system components. VCI functions as a specialised intermediary that finances uncertainty, screens and monitors high-growth ventures, and accelerates diffusion (Klingler-Vidra, 2021). Foundational accounts describe the VC "production function" (fundraising, deal sourcing, contracting and monitoring, exits) and link micro deal mechanics with broader ecosystem outcomes (Lerner & Hardymon, 2020; Feld & Mendelson, 2021). Complementing case-based perspectives, quantitative evidence on entrepreneurial finance mechanisms underscores the role of national conditions that we examine at the country level (Smith & Smith, 2019). At a macro level, a growing body of evidence associates VCI with innovation and growth, particularly in technology-intensive sectors (Margaryan & Terzyan, 2023; Wang et al., 2023; Khan et al., 2021; Pradhan et al., 2018; Karahan, 2016; Pantea & Tkačik, 2024).

The literature increasingly frames VCI as systemically important within innovation ecosystems, especially for SMEs whose growth prospects hinge on scaling intangible, high-uncertainty projects. European evidence stresses context: effects and determinants of VCI differ across regions and stages of development, so results from North America or Asia cannot be generalised uncritically to Europe. Recent European syntheses underscore this heterogeneity and the concentration of published evidence in a subset of Western/Northern countries, motivating comparative work that aligns indicators with regional realities (e.g., digital readiness, institutional quality, and knowledge outputs), and a new European sentiment index built on a survey of 379 VC decision-makers finds overall optimism but with meaningful variation by stage (later-stage > seed), sector (ICT/Life Sciences > cleantech), and location (muted UK/IE market sentiment despite stronger views of own portfolios), reinforcing that supply-side expectations are uneven across Europe (Diegel et al., 2020). This regional nuance is also central to Europe-focused reviews, which call out the risks of importing policy templates and the need to tailor interventions to local bottlenecks (Pantea & Tkačik, 2024; Haslanger, Lehmann, & Seitz, 2023; Lohwasser, 2020; Rosenbusch, Brinckmann, & Müller, 2013; Tykvová, 2018a, 2018b), and to comparative evidence that institutional differences systematically shape VC activity across countries (Grilli, Latifi, & Mrkajic, 2019).

Institutional quality shapes the transaction costs and enforceability conditions under which VC can thrive. Better government effectiveness, regulatory quality, and rule of law reduce search, contracting, and scaling frictions, improving the expected pay-off to risk capital. Comparative work links entrepreneurial finance and VCI inflows to these institutional features (e.g., Kumar & Malodia, 2011; Nawab Khan et al., 2021). In Europe, the policy debate centres on a structural VC gap relative to the United States and the need to expand private risk capital (European Investment Bank, 2019; Duruflé et al., 2017; Quas et al., 2022). Investor-side evidence complements this institutional view: stage, sector, and geography condition expectations and deployment, suggesting that medium-run country characteristics operate alongside cyclical sentiment (Diegel et al., 2020). Related macro evidence from post-transition EU economies indicates that fiscal consolidations did not deliver growth payoffs, underscoring the limits of generic policy templates (Burnać, Visković, & Nikolić, 2024).

Innovation inputs, particularly R&D intensity (GERD) and human capital & research, expand the pipeline of investable opportunities and deepen the talent base required to scale them. R&D expenditure raises the supply of inventions; human capital and research capacity improve the quality of entrepreneurial teams and absorptive capacity, strengthening the signals investors use in selection (Wang et al., 2023; Margaryan & Terzyan, 2023; Khan et al., 2021; Pradhan et al., 2018). Firm-level mechanisms such as absorptive capacity (Jeong, Kim, Son, & Nam, 2020) provide microfoundations for these country-level relationships. Consistent firm-level results from Croatia show that entrepreneurial, market, and learning orientations are positively associated with innovativeness and performance, reinforcing the channel from human capital and organisational capabilities to investable opportunities and, ultimately, to VCI (Šlogar & Andrijanić, 2023). European regional evidence also indicates that R&D effects are conditional on local innovation capacity: across NUTS2 regions, R&D tends to generate employment mainly where innovation levels are medium to high (Destefanis & Rehman, 2023). Accordingly, countries with higher GERD and stronger human-capital & research profiles are expected to attract more VCI.

Knowledge creation and intellectual property deepen appropriability and inform exit prospects. Patent intensity, including PCT applications, and broader knowledge & technology outputs provide credible signals about the potential scalability of technologies and their competitive defensibility. Empirical work finds positive links between IP measures and VC participation or deal values (Pradhan et al., 2018; Margaryan & Terzyan, 2023; Karahan, 2016), and Europe-wide evidence connects higher patenting and greater VCI to increases in high-tech exports, suggesting a pathway from finance and knowledge assets to tradable competitiveness, especially relevant for smaller, open economies (Margaryan & Terzyan, 2023). Sectorally, European cleantech offers a stringent stress test: using machine-learning identification (24,538 cleantech firms; 401 first-time VC rounds, 1988–2023) and matched controls, investors select already faster-growing targets yet still deliver additional growth, most pronounced in the short term, evidence that VC supports green-transition technologies while discounting sector-specific risk (Ambrois, Croce, & Ughetto, 2025). Sustainability-oriented studies similarly report that VCI can contribute to progress on Sustainable Development Goals (SDGs) when capital targets the right innovation domains and complementary conditions are present (Gucciardi, 2024). Parallel sectoral evidence from healthcare shows European early-stage VCI lagging behind U.S. levels due to uneven financing patterns and aligns with findings that ICT readiness, knowledge creation, and technology outputs are direct predictors of VCI (Karpa & Grginović, 2020).

Translational linkages between research and markets also matter. University–industry collaboration can reduce information asymmetries by certifying teams and technologies, facilitate team formation, and enable access to complementary assets. European evidence also shows that investing in the inputs to UIC (knowledge, networking, and R&D) translates into stronger collaboration outputs: using PLS-SEM on EU and Western Balkan data (2015–2018), Ćudić, Alešnik, & Hazemali (2022) find that countries with higher UIC "predictors" achieve higher UIC performance, reinforcing our inclusion of university–industry collaboration and R&D as relevant determinants for VCI in a European setting. Where these linkages are dense, the pipeline of VC-backable opportunities tends to be thicker and better signalled; we therefore expect stronger collaboration to correlate with higher VCI at the country level. Eco-innovation research further shows that national innovation systems, governance quality, and knowledge/technology outputs structure green innovation outcomes, providing a conceptual bridge from VCI inputs to sustainability outputs (Chaparro-Banegas et al., 2024).

Digital readiness conditions the scalability of new ventures. ICT access and use lower diffusion and coordination costs, expand addressable markets, and favour software-intensive models that are typically complementary to VC finance. Cross-country evidence links ICT readiness to entrepreneurial dynamism and innovation outputs (Kumar & Malodia, 2011; Nawab Khan et al., 2021), suggesting that countries with higher ICT access and use should also attract more VCI. Digital platforms provide a concrete mechanism linking ICT readiness to VC investability: rapid multi-market scaling, network effects, and data advantages raise expected returns and shorten the path to credible exits. The internationalisation and eventual acquisition of Wolt – a Finnish food-delivery start-up scaled across Europe, Asia and the Middle East before its US$8.1bn all-stock acquisition by DoorDash in 2021 – illustrate how platform economics, localisation strategies and M&A markets interact to validate VC theses during external shocks such as COVID-19 (Laine & Salihu, 2024). Beyond individual cases, a joint innovation – digitalisation composite built from GII and the DESI index for EU member states shows highly stable leaders (SE, NL, FI, DK) and a persistent north-central vs. south-eastern gap; panel models highlight wealth, employment, researchers, and infrastructure as levers and confirm that digitalisation and innovation move together – conditions that are also conducive to VCI (Martí & Puertas, 2024). These patterns dovetail with evidence from digital-intensive entrepreneurship and fintech in Europe, where selection, scaling, and survival are shaped by innovation capacity and information frictions common in early-stage finance (e.g., Germany's fintech ecosystem).

At the same time, not all innovation-adjacent indicators are expected to predict VCI uniformly within Europe. Creative goods and services capture cultural and design-intensive activities that often rely on project-based or royalty finance rather than equity-backed scale-ups; measurement also emphasises tradables over start-up pipelines. ICT services exports can be driven by a few large incumbents or outsourcing hubs and need not map onto domestic early-stage ecosystems. Finally, within the EU, political or operational stability may display limited cross-country variance beyond a threshold; micro-institutions (contract enforcement, regulatory quality) and innovation capacity are more likely to be binding constraints for VCI. These mechanisms are consistent with our empirical finding that such indicators are not significant determinants of VCI over 2013–2020.

European evidence is also unevenly distributed across countries. Pantea & Tkačik (2024) emphasise a European focus to inform EU policy, contrasting with global reviews (Haslanger, Lehmann, & Seitz, 2023; Lohwasser, 2020; Rosenbusch, Brinckmann, & Müller, 2013; Tykvová, 2018b) that rely heavily on North American and Asian estimates or cross-country samples dominated by those regions. Since VC effects can systematically differ across regions and countries (Grilli, Latifi, & Mrkajic, 2019; Haslanger et al., 2023; Lohwasser, 2020; Tykvová, 2018a), direct generalisation to Europe is problematic. We add to this literature by evaluating determinants in a European comparative setting, which remains relatively under-researched, including smaller EU and CEE countries. Even widely used levers, such as attracting FDI, have shown limited growth effects across CEE new member states, further motivating region-specific diagnostics (Todorov, Tsvetkov, Mirchova, & Durova, 2023). Consistent with this, a Europe-specific systematic review of high-tech start-ups finds mixed but generally positive effects of VC on growth, innovation and professionalisation, while emphasising selection, stage and institutional context as moderators of impact, points that dovetail with investor-sentiment heterogeneity and sectoral results above (see, e.g., Croce, Martí, & Murtinu, 2013; Cumming, Grilli, & Murtinu, 2017; Quas, Martí, & Reverte, 2021).

Public and private finance instruments interact with these channels. Post-crisis work shows SMEs may resort to leasing and other non-bank instruments to bridge financing gaps (Kraemer-Eis & Lang, 2012). These tools can ease collateral constraints and facilitate equipment acquisition under tighter credit conditions; however, they do not substitute for the risk-bearing capital, governance, and scaling support associated with VC. In innovation-intensive contexts, characterised by high uncertainty and intangible assets, such instruments address specific constraints but are unlikely to replicate VCI's roles in selection, monitoring, and acceleration. Evidence from Hungary's National Development Programmes (2007–2013) also shows that while public VC can expand equity availability, portfolio quality may deteriorate when public funding is excessive or poorly targeted, highlighting the need for alignment with market selection (Kállay & Jáki, 2020). Transparency in fund vehicles influences investor confidence and market efficiency (Makushina, 2022), and early-stage business angels report administrative and legislative frictions that can bind more tightly than headline macro conditions (Zinecker et al., 2022).

In sum, the literature indicates clear country-level pathways through which institutions, innovation inputs, knowledge creation and IP, university–industry collaboration, and digital readiness should be positively associated with VCI. Conversely, creative goods and services, ICT services exports, and broad measures of political or operational stability may not track VCI once European institutional thresholds are met.

3. METHODS

3.1. Research Design and Scope

We examine cross-country determinants of VCI in Europe as systematic differences in VCI associated with national innovation-system indicators. The design is observational and comparative; we therefore make no causal claims. Guided by European evidence on ecosystem heterogeneity, we compare VCI across ordered levels ("tiers") of institutional quality, innovation inputs, digital readiness, and knowledge outputs that are especially relevant for SME scaling and investor selection. The literature motivates the domain focus and the use of tiered comparisons; the empirical specification is strictly within the country–year panel for European states.

3.2. Data Sources, Units, and Sample

Annual VCI totals (EUR millions) for 22 European countries/groups from 2013–2020 were obtained from Invest Europe (2022). Innovation-system indicators for the same period were drawn from the Global Innovation Index (GII, Dutta, Lanvin, & Wunsch-Vincent, 2020). The analytic unit is the country–year, yielding 176 observations (22 × 8). All GII indicators use the original 0–100 scaling.

Two entries in the VCI series are aggregated by the source rather than single countries: "CEE" (Central & Eastern Europe aggregate) and "Other EU." We follow the source definitions for these groupings; their member lists are provided for reproducibility in Appendix A, Table A1. This preserves alignment with Invest Europe's reporting while allowing individual countries (e.g., France, Germany, Netherlands) to be analysed separately.

3.3. Variables and Tier Construction

The dependent variable is VCI (EUR millions). Fourteen GII indicators serve as determinants: Business environment; Creative goods and services; Government effectiveness; Gross expenditure on R&D (GERD); Human capital and research; ICT access; ICT services exports; ICT

Table 1. Cross-Country Dispersion of GII Indicators (0–100 Scale), 2020; Diff = Max – Min.

No	Variable	Max	Min	Diff
1	Business environment	93.1	60.1	33
2	Creative goods and services	62.12	14.7	47.42
3	Government effectiveness	100	32.41	67.59
4	Gross expenditure on R&D	86.11	7.97	78.14
5	Human capital and research	68.11	27.7	40.41
6	ICT access	95.4	57.2	38.2
7	ICT services exports	100	5.8	94.2
8	ICT use	90.3	29.42	60.88
9	Knowledge and technology outputs	63.92	20.4	43.52
10	Knowledge creation	78.68	9.48	69.2
11	Patent applications by origin	100	0.98	99.02
12	PCT international applications by origin	100	0.67	99.33
13	Political and operational stability	100	58.34	41.66
14	University/industry research collaboration	82.8	25.6	57.2

use; Knowledge and technology outputs; Knowledge creation; Patent applications by origin; PCT international applications by origin; Political and operational stability; University–industry research collaboration.

For each indicator, we classified all country–year values into five ordered tiers (Q1–Q5) using pooled equal-frequency quintiles over 2013–2020 (Q1 lowest, Q5 highest). This approach preserves comparability across time and supports interpretation as relative national standing on each determinant.

To document cross-sectional dispersion in the determinants, we report the observed 2020 range for all 14 indicators (max, min, difference) in Table 1.

The largest range (more than 90) is obtained for variables PCT international applications by origin. patent applications by origin and ICT services exports, and the smallest (less than 45) for variables Business environment, ICT access, Human capital and research, Political and operational stability, and Knowledge and technology outputs.

3.4. Statistical Analysis

Analyses were performed in IBM SPSS. We first describe VCI by country and year (Table 1; Figure 1 in Results) and benchmark cross-country heterogeneity via a one-way ANOVA with Country as the factor and VCI as the outcome; significant omnibus results are followed by Tukey's HSD for pairwise contrasts, with full matrices relegated to the Appendix.

Determinant tests proceed indicator-by-indicator: for each of the 14 GII variables, we estimate a one-way ANOVA with Tier (Q1–Q5) as the factor and VCI as the outcome. We report F-statistics and p-values in a consolidated table (Table 4 in Results), apply Tukey's HSD where appropriate to identify homogeneous subsets, and discuss monotonic patterns across tiers. For each ANOVA we compute η^2 (or partial η^2) with 95% confidence intervals and assess assumptions via residual diagnostics and Levene's test. When variance homogeneity is violated, we confirm results with Welch's ANOVA and Games–Howell post-hoc tests; conclusions are unchanged.

To guard against multiplicity, we emphasise effect sizes and patterns across indicators; unadjusted p-values are reported for transparency, and robustness to Holm–Bonferroni correction is documented in the Appendix.

3.5. Hypotheses

To investigate the determinants influencing VCI size, we formulated the following hypotheses:

H1. The size of the VCI depends significantly on the level of innovativeness in the specific country, where the level of innovation affects the quantity of VCI.

H2. There are determinants that significantly affect the VCI.

From H2, we defined four specific hypotheses:

HS1: Business environment, Government effectiveness, Gross expenditure on R&D, and Political and operational stability significantly affect VCI.

HS2: ICT access, ICT services exports, and ICT use significantly affect VCI.

HS3: Human capital and research, Knowledge and technology outputs, and Knowledge creation significantly affect VCI.

HS4: Creative goods and services, Patent applications by origin, PCT international applications by origin, and University–industry research collaboration significantly affect VCI.

In the Results and Discussion section, each ANOVA is mapped explicitly to HS1–HS4 and interpreted as full, partial, or no support.

3.6. Robustness and Sensitivity

To ensure patterns are not driven by outliers, we re-estimated all significant ANOVAs after excluding France and Germany; the direction and significance of results persisted. We replicated analyses using equal-width (min–max) bins instead of quintiles and with log-transformed VCI; findings were qualitatively unchanged. We also verified that conclusions were unaffected by treating "country groups" as single units in sensitivity runs.

3.7. Missing Data and Reproducibility

The Invest Europe and GII series were complete for the 22 countries and the 2013–2020 window; no imputation was required. Tier cut-points, ANOVA outputs, post-hoc tables, and effect-size calculations are archived in the Appendix to enable replication.

3.8. Limitations

This is a descriptive, cross-country comparative design, so results speak to associations rather than causation. Tiering compresses within-tier variation and may mask non-linearities; robustness checks with alternative binning and transformed outcomes mitigate but cannot eliminate this concern. VCI totals aggregate stages and sectors, preventing separation of early- versus late-stage dynamics or sectoral composition (e.g., cleantech vs. ICT). Some countries are analysed as groups, which can blur within-group heterogeneity. Although GII indicators are harmonised, measurement error and limited within-EU variance on some dimensions (e.g., political/operational stability near a common threshold) can attenuate differences. Finally, Invest Europe focuses on formal VC; informal finance and corporate venture activity may be under-reflected, particularly in smaller markets.

4. RESULTS AND DISCUSSION

VCI varies markedly across European countries over 2013–2020. Table 2 reports annual totals and Figure 1 traces the time paths.

Both displays reveal a persistent upper tail composed of France and Germany, a second tier led by the Netherlands, a middle band including Denmark, Spain, Sweden and Belgium,

Table 2. VCI by Country and Year (EUR Millions), 2013–2020

	2013	2014	2015	2016	2017	2018	2019	2020
Austria	26036	24826	30560	29447	39489	64913	80383	86853
Baltic	6215	25406	19071	20708	12627	13909	37116	32315
Belgium	118277	135124	98406	168915	213490	238817	316512	375812
Bulgaria	1702	1440	9222	6814	6343	9633	10088	38623
CEE	7628	9545	13093	14921	765	1455	5317	20702
Czech Republic	832	5587	11790	16594	20456	40077	48059	39241
Denmark	199649	201866	283918	297866	264472	615969	413915	362280
Finland	103552	100945	104024	113846	93841	138830	153839	257974
France	764039	717689	988810	1074387	1335322	1669854	2309306	2101708
Germany	665549	604836	758391	1005861	907071	1512259	1756182	1564675
Greece	9246	10645	8691	15355	10158	19127	42151	21671
Hungary	22430	41376	59153	38706	23883	57754	131631	124531
Ireland	91899	64659	93729	62412	100892	155178	138437	188455
Italy	76804	59220	69824	73195	144549	149986	213530	333625
Luxembourg	42318	32998	42691	25379	102979	105497	151252	167935
Netherlands	168207	185064	238033	329595	456454	527216	814642	628266
Other EU	0	0	0	0	0	97	2000	940
Poland	23508	26305	36518	40110	22358	28523	44189	73957
Portugal	30430	45375	71815	17728	20155	24035	52373	39087
Romania	3500	2435	1236	1500	2500	2281	14219	8586
Spain	198138	189333	208209	227968	319623	384257	425211	470506
Sweden	222524	206699	170822	217060	256864	324409	403942	418941
Total	2782483	2691373	3318006	3798367	4354291	6084076	7564294	7356683

Source: Invest Europe, 2022.

and a lower tail in which Romania, Bulgaria and Greece appear consistently. This profile of dispersion motivates our first proposition (H1) that higher levels of "innovativeness" are associated with higher VCI.

Following the tiering strategy (Methods 3.3), we first tested cross-country differences in VCI with a one-way ANOVA using Country as the factor. The omnibus test confirms substantial heterogeneity ($F(21,154)=31.941$, $p<.001$). Post-hoc Tukey's HSD pinpoints where gaps lie: Germany's mean VCI exceeds all countries except France, and France exceeds all except Germany; the difference between Germany and France is not significant. The Netherlands also sits signif-

Figure 1. VCI Time Paths, 22 Entries, 2013–2020.

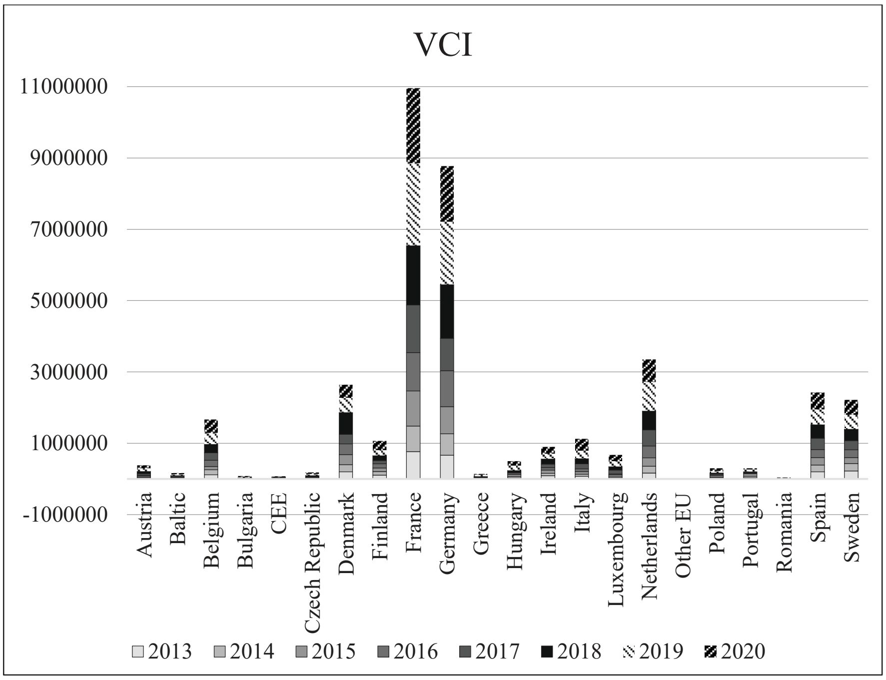
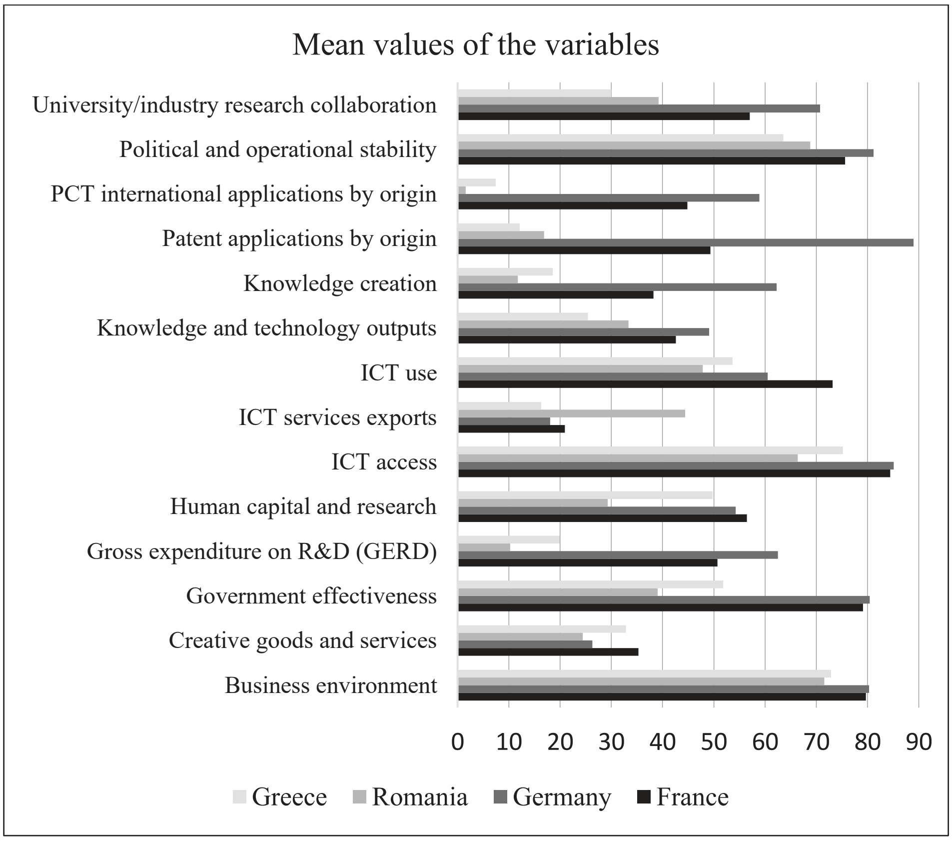


Table 3. Venture Capital Investments – Multiple Comparisons (Tukey HSD)

Tukey HSD						
(I) Country		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
CEE	Netherlands	-409256.37500*	88403.92	0.002	-732650.57	-85862.18
Denmark	Other EU	329612.25000*	88403.92	0.040	6218.05	653006.45
Netherlands	CEE	409256.37500*	88403.92	0.002	85862.18	732650.57
Netherlands	Czech Republic	395605.12500*	88403.92	0.003	72210.93	718999.32
Netherlands	Greece	401304.12500*	88403.92	0.002	77909.93	724698.32
Netherlands	Hungary	356001.62500*	88403.92	0.015	32607.43	679395.82
Netherlands	Luxembourg	334553.50000*	88403.92	0.034	11159.30	657947.70
Netherlands	Poland	381501.12500*	88403.92	0.005	58106.93	704895.32
Netherlands	Portugal	380809.87500*	88403.92	0.005	57415.68	704204.07
Netherlands	Romania	413902.50000*	88403.92	0.001	90508.30	737296.70
Netherlands	Other EU	418055.00000*	88403.92	0.001	94660.80	741449.20
Romania	Denmark	-325459.75000*	88403.92	0.047	-648853.95	-2065.55
Other EU	Denmark	-329612.25000*	88403.92	0.040	-653006.45	-6218.05

* The mean difference is significant at the 0.05 level.

Figure 2. Descriptive Analysis for Greece, Romania, Germany and France



icantly above a set that includes CEE, the Czech Republic, Greece, Hungary, Luxembourg, Poland, Portugal, Romania, and "Other EU." Romania's mean is significantly below Denmark's as well. Selected contrasts are reported in Table 3; the full pairwise matrix is provided in the Appendix.

To illustrate how these aggregate differences align with innovation capacity, we contrasted the eight-year means for France and Germany (high-VCI leaders) with Romania and Greece (low-VCI cases). Figure 2 shows that the largest gaps favouring France and Germany occur in patent applications (by origin), PCT applications, knowledge creation, and gross expenditure on R&D (GERD).

These patterns are consistent with H1: countries with stronger innovation stocks and flows tend to attract and deploy more venture capital.

We then turned to the determinants analysis. For each of the 14 Global Innovation Index (GII) indicators, country-year observations were partitioned into five tiers (Q1–Q5), and we estimated a one-way ANOVA of VCI on Tier. Table 4 summarises the omnibus tests.

Table 4. ANOVA Results

	Independent variable (Index)	ANOVA
1	Business environment	[F(4, 171) = 8,077, p = .000]
2	Creative goods and services	[F(4, 171) = 1,080, p = .368]
3	Government effectiveness	[F(4, 171) = 7,227, p = .000]
4	Gross expenditure on R&D	[F(4, 171) = 14,970, p = .000]
5	Human capital and research	[F(4, 171) = 17,334, p = .000]
6	ICT access	[F(4, 171) = 10,790, p = .000]
7	ICT services exports	[F(4,171) = 0,837, p = 0,503]
8	ICT use	[F(4, 171) = 6,212, p = .000]
9	Knowledge and technology outputs	[F(4, 171) = 7,283, p = .000]
10	Knowledge creation	[F(4, 171) = 6,948, p = .000]
11	Patent applications by origin	[F(4, 171) = 12,143, p = .000]
12	PCT international applications by origin	[F(4, 171) = 13,486, p = .000]
13	Political and operational stability	[F(4, 171) = 1,105, p = .356]
14	University/industry research collaboration	[F(4, 171) = 4,392, p = .002]

Eleven of fourteen indicators display significant between-tier differences in VCI at p < .001 or p < .01, covering institutions (business environment, government effectiveness), innovation inputs (GERD, human capital & research), digital readiness (ICT access, ICT use), and knowledge outputs (knowledge & technology outputs, knowledge creation, patent activity including PCT). Three indicators are not significant – creative goods & services (p = .368), ICT services exports (p = .503), and political & operational stability (p = .356) – consistent with limited within-EU variance or financing logics that do not map to equity-backed scaling.

To anchor magnitude, consider GERD: mean VCI rises monotonically across tiers, with the Q5 vs. Q1 contrast large in practical terms (η^2 = .26, 95% CI [.15, .35]; omnibus F(4, 171) = 14.970, p < .001). Representative post-hoc patterns for other significant indicators are similar: higher tiers in Human capital & research and Knowledge creation are associated with higher VCI; Patent applications by origin and PCT applications by origin separate cleanly into two or three homogeneous subsets with the top tier hosting the largest VCI aggregates. Digital readiness shows graded relationships: ICT access forms three homogeneous groups with VCI increasing by tier; ICT use separates into two groups, again with higher tiers associated with higher VCI. Institutional quality matters: Business environment forms two homogeneous subsets, with the top tier significantly above all others; Government effectiveness also yields two subsets, separated around an index level near ~68. Where ANOVA assumptions were violated, Welch's ANOVA and Games–Howell post-hoc tests confirmed the same qualitative conclusions.

The non-significance of political & operational stability likely reflects high, compressed scores across EU members during the window, limiting discriminatory power. ICT services exports can be dominated by a small number of large incumbents or offshore service hubs, which may not correlate with domestic early-stage ecosystems; creative goods & services often rely on project-based or royalty finance rather than equity-backed scale-ups, diluting any VCI signal.

Country-level descriptive contrasts reinforce the tiered patterns. Comparing the four illustrative entries – France and Germany (high-VCI) versus Romania and Greece (low-VCI) – the largest gaps appear in patent applications (origin), PCT applications (origin), knowledge creation, and GERD (Figure 2). These domains align with investor selection criteria and with national capacity to produce scalable, defensible innovations. We standardise figure captions to read "VCI by [indicator], quintile tiers (Q1–Q5); means ± 95% CI" for all indicator plots and renumber sequentially (no duplicates).

Figure 3. VCI Depending on the Business Environment

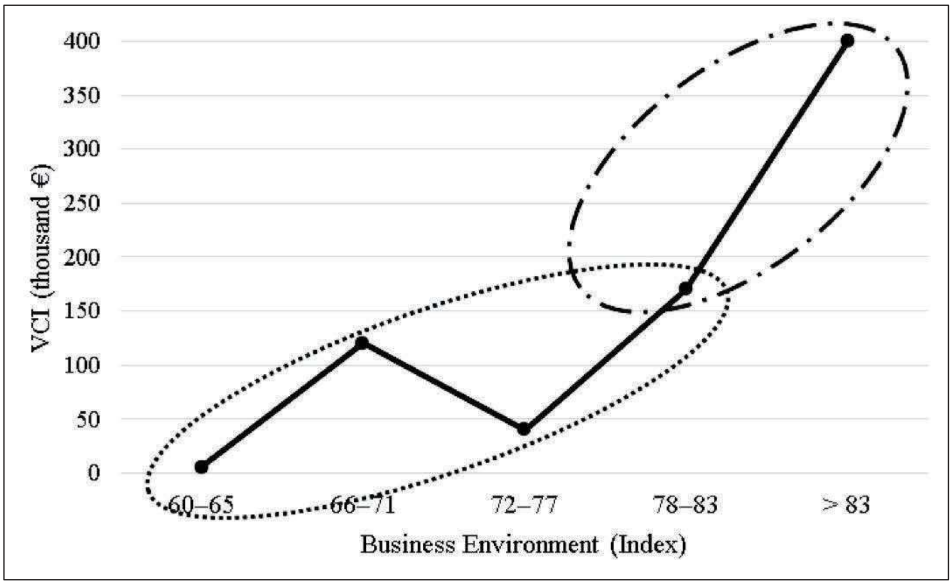
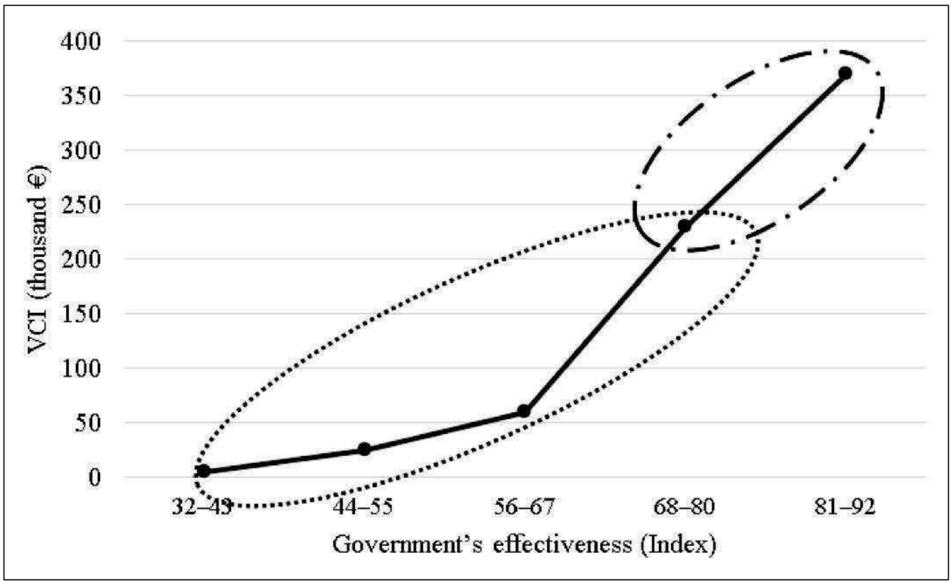


Figure 4. VCI Depending on the Government's Effectiveness



4.1. Institutional Conditions (HS1)

Business environment and government effectiveness both exhibit clear monotonic associations with VCI. Tukey's HSD indicates that the highest business-environment tier (Q5) differs from all lower tiers, forming two homogeneous groups: low/medium tiers and high tiers. This is shown in Figure 3.

Government effectiveness similarly separates into two groups around an index value near ~68 (Figure 4).

Figure 5. VCI Depending on the Gross Expenditure on R&D

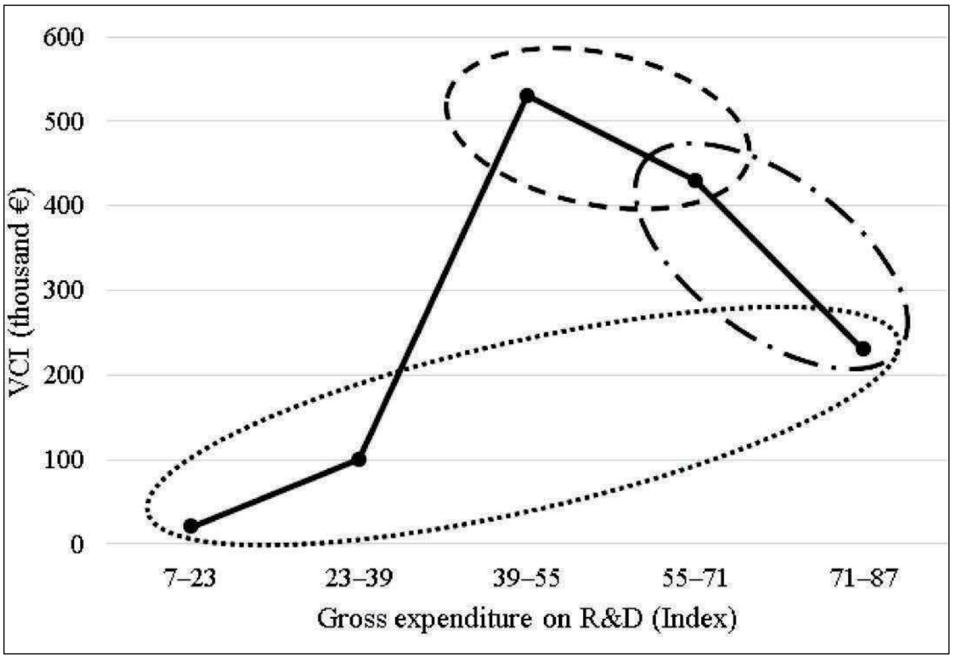
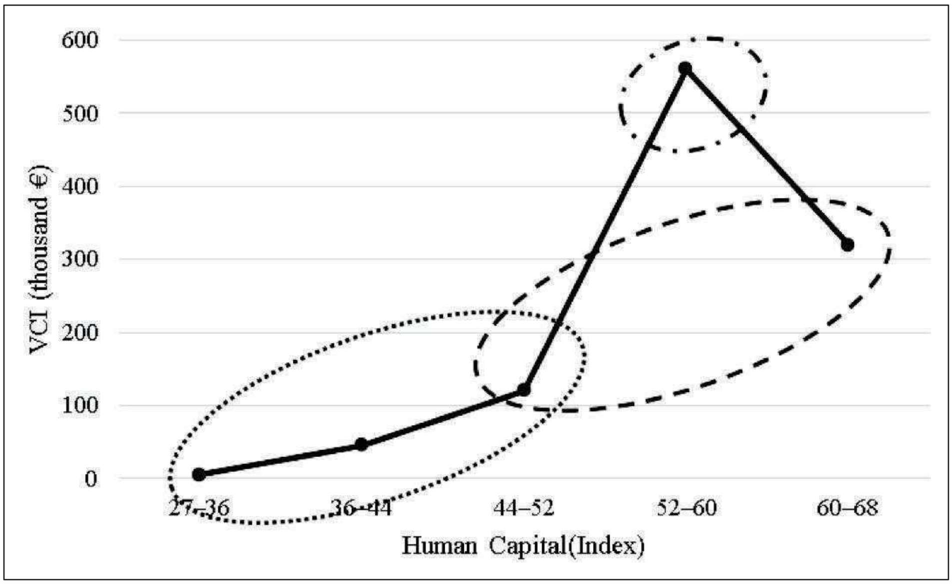


Figure 6. VCI Depending on the Human Capital



Political/operational stability, by contrast, is not significant (p=.356), plausibly reflecting limited within-EU dispersion around a high common threshold. Taken together, HS1 is largely supported: business environment and government effectiveness matter; broad stability does not in this sample.

Figure 7. VCI Depending on the ICT Access

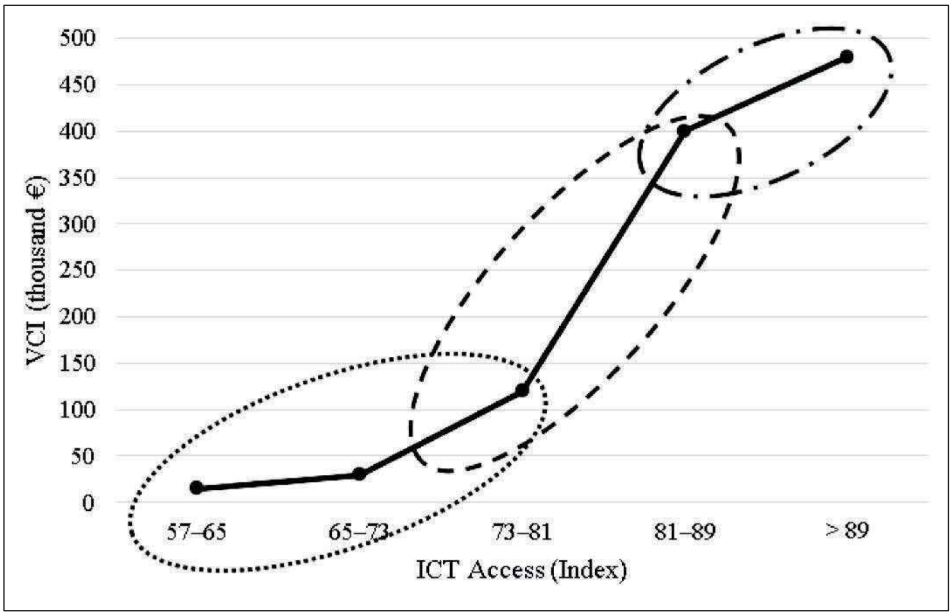
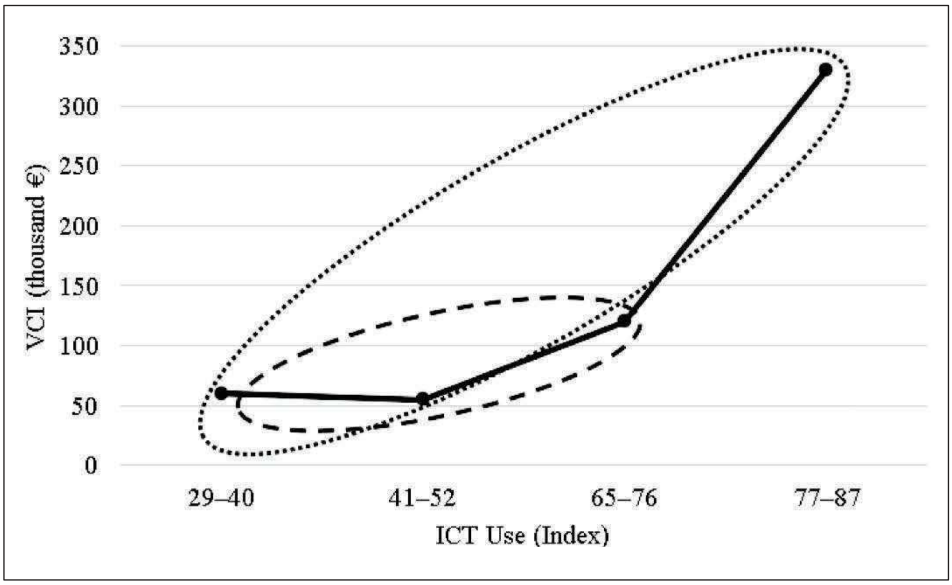


Figure 8. VCI Depending on the ICT Use



4.2. Innovation Inputs (HS1 & HS3)

GERD shows three statistically homogeneous subsets, with higher tiers associated with larger VCI (Figure 5).

Human capital & research also partitions into three groups with a generally upward trend (Figure 6).

Figure 9. VCI Depending on the Knowledge and Technology Outputs

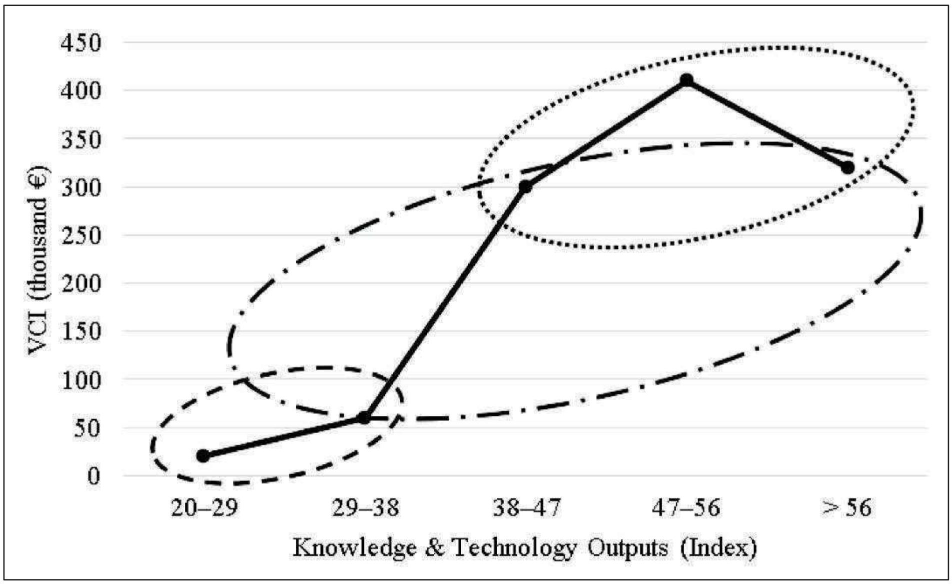
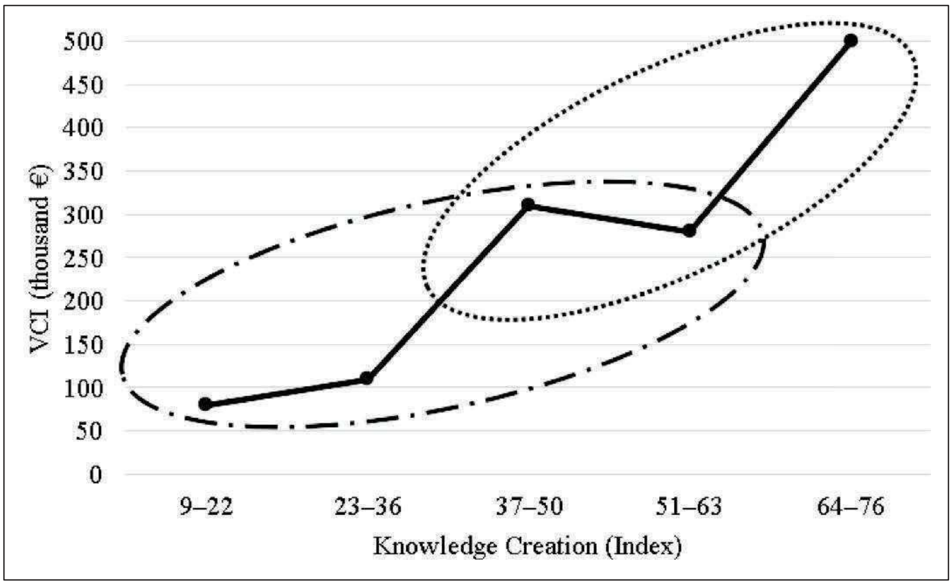


Figure 10. VCI Depending on the Knowledge Creation



These results support the expectation that deeper input bases (funding and talent/research capacity) relate to larger VCI pools.

4.3. Digital Readiness (HS2)

ICT access forms three homogeneous groups with higher tiers linked to higher VCI (Figure 7).

Figure 11. VCI Depending on the Patent Applications by Origin

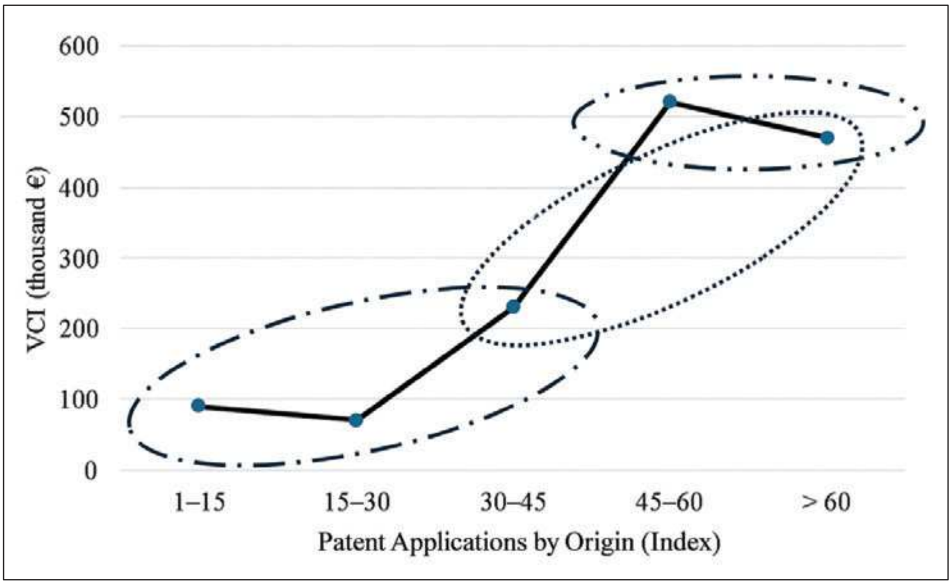
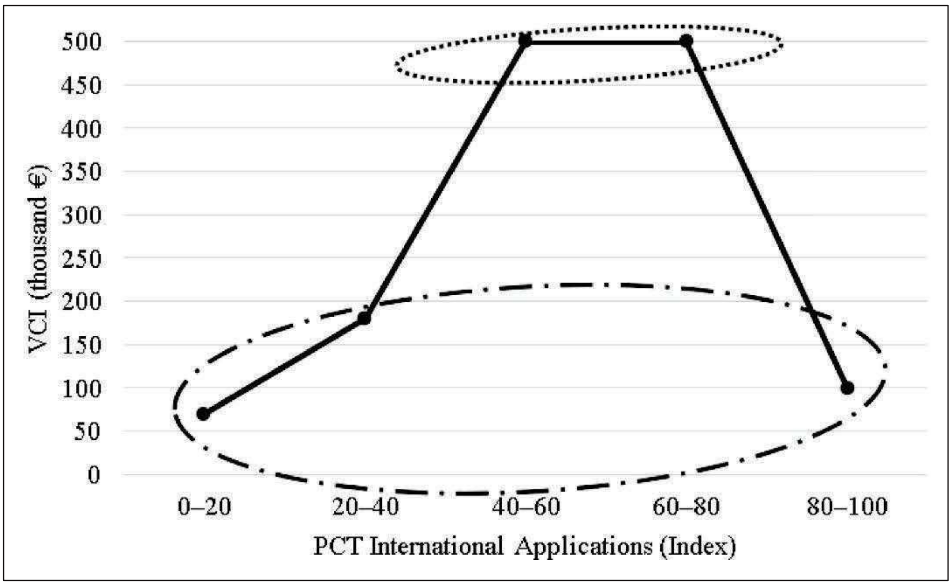


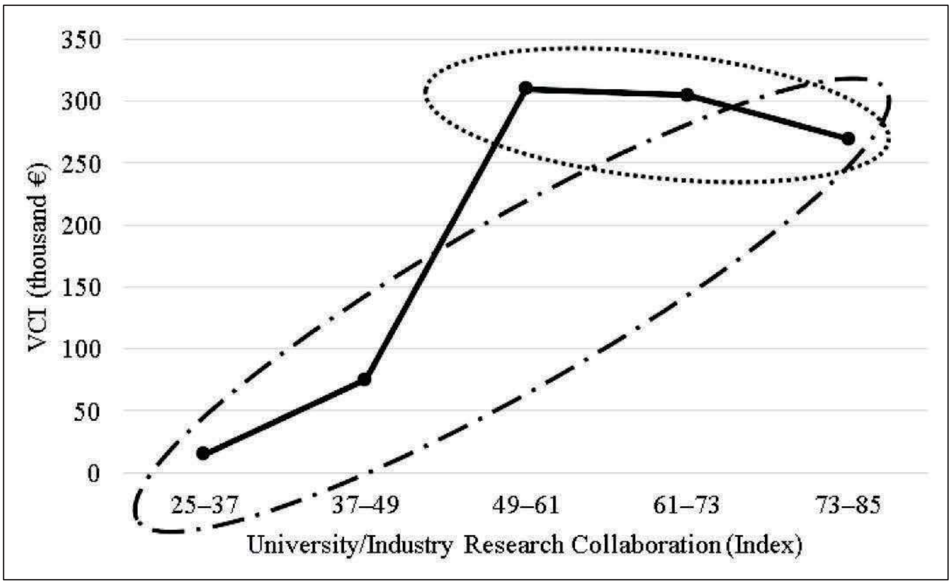
Figure 12. VCI Depending on the PCT International Applications



ICT use forms two groups with a pronounced upward shift at higher usage (Figure 8).

ICT services exports do not discriminate VCI across tiers (p=.503), consistent with the notion that export intensity can be driven by a few incumbents and may not track early-stage ecosystems. Overall, HS2 is partially supported: ICT access and use matter; ICT services exports do not.

Figure 13. VCI Depending on the University/Industry Research Collaboration



4.4. Innovation Outputs and Knowledge Creation (HS3 & HS4)

Knowledge & technology outputs and knowledge creation each display significant between-tier differences, with higher tiers associated with higher VCI (Figures 9–10).

Intellectual-property intensity shows a similar pattern: patent applications by origin (three groups) and PCT applications (two groups) both differentiate VCI (Figures 11–12).

Finally, university–industry research collaboration forms two groups, with higher collaboration associated with higher VCI (Figure 13).

Together these findings support HS3 (human capital, knowledge & technology outputs, and knowledge creation) and support the HS4 elements tied to patents and collaboration.

4.5. Non-Significant Indicators (HS4 remainder)

Creative goods & services does not separate VCI across tiers (p=.368), aligning with the expectation that project-based cultural outputs are financed through channels other than VC in Europe. This, together with the non-significance of ICT services exports noted above, helps delineate which GII components are most informative for VCI.

4.6. Link Back to the Hypotheses

Linking back to the hypotheses, the evidence is coherent. H1, that VCI depends on the country's innovativeness, is supported by the country contrasts (France/Germany vs. Romania/Greece) and by the tiered results for GERD, knowledge creation, patenting, and digital readiness. H2, that significant determinants exist, is supported: eleven of fourteen indicators show significant between-tier differences. HS1 is largely supported: the business environment and government effectiveness are significant; stability is not. HS2 is partially supported: ICT access and ICT use are significant, ICT services exports is not. HS3 is supported: human capital & research, knowledge & technology outputs, and knowledge creation are significant. HS4 is largely supported: patents (origin and PCT) and university–industry collaboration are significant, creative goods & services is not. In sum, European VCI is highest where institutional quality is strong, R&D and human-capital inputs are deep, digital readiness is advanced, and knowledge/IP outputs are abundant; indicators with limited within-EU variance (stability) or different financing logics (creative outputs, ICT services exports) are not informative for VCI in this period.

These conclusions are robust to alternative specifications described in the Methods (log-transforming VCI, using equal-width bins rather than quintiles, and excluding France and Germany). Overall, European VCI is highest where institutional quality is strong, R&D and human-capital inputs are deep, digital readiness is advanced, and knowledge/IP outputs are abundant, while indicators with little within-EU variation (stability) or reflecting different financing logics (creative outputs; ICT services exports) are not informative for VCI over this period.

5. CONCLUSION

This study set out to explain cross-country differences in venture capital investment (VCI) across 22 European economies over 2013–2020 by testing whether VCI systematically varies with national innovation-system indicators. Using Invest Europe VCI data and 14 Global Innovation Index measures tiered into quintiles, we find large and persistent between-country gaps, led by France and Germany, followed by a second tier (e.g., the Netherlands), and a lower tail (e.g., Romania, Bulgaria, Greece). Against this backdrop, our tiered ANOVAs show that VCI is highest where institutional quality is strong, innovation inputs are deep, digital readiness is advanced, and knowledge/IP outputs are abundant.

Taken together, the results support H1 and H2 and, within H2, largely confirm HS1, HS3, and HS4 and partially confirm HS2. Eleven of the fourteen indicators exhibit significant between-tier differences in VCI: business environment, government effectiveness, GERD, human capital and research, ICT access, ICT use, knowledge and technology outputs, knowledge creation, patent applications, PCT applications, and university–industry collaboration. By contrast, creative goods and services, ICT services exports, and political/operational stability do not discriminate VCI within this European sample, consistent with limited within-EU variance (stability) or financing logics that are not VC-intensive (creative outputs; export outsourcing).

These patterns have clear policy implications. Countries aiming to raise VCI should prioritise reforms and investments that (i) improve government effectiveness and the business environment (contracting, regulation, administrative capacity), (ii) expand innovation inputs (public and private R&D; researcher density; advanced training), (iii) accelerate digital readiness (broadband access and sophisticated use), and (iv) strengthen translational linkages (university–industry collaboration, IP quality, and routes to scale). For smaller or catching-up economies, targeted programmes that build patenting capacity and knowledge outputs, coupled with credible institutional upgrades and digital infrastructure, are likely to be more effective in attracting VC than generic support or reliance on creative-industry exports. Non-equity instruments (e.g., leasing) can help SMEs acquire assets but are complements rather than substitutes for the risk-bearing, governance, and scaling functions distinctive to VC.

Our findings also speak to policy transferability beyond Europe. While the broad channels, institutions, inputs, digital readiness, and knowledge outputs, are general, their salience is context dependent. Developing economies considering European policy templates should first diagnose local bottlenecks along these dimensions, adapt instruments to their administrative capacity, and recognise that VC responds to credible improvements in appropriability (IP), deal flow (R&D and human capital), and scalability (digital infrastructure and market integration).

The study's scope and design impose limits. Results are associative, not causal; the tiering strategy sacrifices within-tier granularity; VCI totals pool stages and sectors and treat some small states as groups; and several indicators show compressed within-EU variance. Nonetheless, robustness checks (alternative binning, log-VCI, exclusion of largest ecosystems) support the stability of the patterns.

Future work should unpack stage and sector heterogeneity, incorporate digital/innovation composites explicitly, and link finance to downstream performance outcomes (innovation output quality, high-tech exports, and sustainability metrics). Combining the present country-level lens with regional or firm-level data would help separate selection from treatment effects and clarify how national determinants translate into investable pipelines for SMEs.

In sum, European VCI concentrates where institutional quality, innovation inputs, digital readiness, and knowledge/IP outputs jointly lower risk and raise expected returns. Aligning policies to these levers offers a pragmatic route to deepen VC markets, expand finance for innovative SMEs, and strengthen Europe's competitiveness.

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APPENDIX 1

Table 1. PostHoc Test – VCI Depending on the Business Environment

(I) Business environment	(J) Business environment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
more than 83	60-65	397042.69	255540.24	0.529	-307508.1199	1101593.5079
	66-71	284207.14*	92559.75	0.021	29010.3565	539403.9263
	72-77	363967.08*	68636.08	0.000	174730.3124	553203.8534
	78-83	229760.03*	69584.40	0.010	37908.6686	421611.3939

* The mean difference is significant at the 0.05 level.

Table 2. Tukey HSD Government Effectiveness – Homogeneous Subsets

Government effectiveness	N	Subset for alpha = 0.05	
		1	2
32-43	10	4381.50	
44-55	26	26613.92	
56-67	29	63057.14	
68-80	45	237742.18	237742.18
81-92	66		374041.53
Sig.		0.170	0.686

Table 3. Tukey HSD, Gross Expenditure on R&D – Homogeneous Subsets

Gross expenditure on R&D	N	Subset for alpha = 0.05		
		1	2	3
7-23	39	16435.64		
23-39	63	92945.68		
71-87	16	229329.00	229329.00	
55-71	30		427602.20	427602.20
39-55	28			534131.25
Sig.		0.115	0.165	0.745

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 28.891.
b. With a Gross expenditure on R&D index of 28.6
c. Table 8. Tukey HSD Human capital and research - Homogeneous Subsets

Table 4. Tukey HSD, ICT Access – Homogeneous Subsets

ICT access	N	Subset for alpha = 0.05		
		1	2	3
57-65	10	13986.90		
65-73	37	28721.14		
73-81	59	124675.44	124675.44	
81-89	54		400514.30	400514.30
more than 89	16			485212.44
Sig.		0.825	0.066	0.926

Table 5. Tukey HSD, ICT Use – Homogeneous Subsets

ICT use	N	Subset for alpha = 0.05	
		1	2
41-52	23	54389.30	
29-40	11	62155.27	62155.27
65-76	52	120299.75	120299.75
77-87	90		330659.16
Sig.		0.924	0.057

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 24.282.
b. The group sizes are unequal. The harmonic mean of the group sizes is used.

Table 6. Tukey HSD – Human Capital and Research – Homogeneous Subsets

Human capital and research	N	Subset for alpha = 0.05		
		1	2	3
27-36	23	8083.48		
36-44	46	48830.26		
44-52	39	121050.62	121050.62	
60-68	32		324844.78	
52-60	36			566707.06
Sig.		0.623	0.086	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 33.359.
b. The group sizes are unequal. The harmonic mean of the group sizes is used.

Table 7. Tukey HSD – Knowledge and Technology Outputs

Venture Capital Investments				
Tukey HSD[a,b]				
Knowledge and technology outputs	N	Subset for alpha = 0.05		
		1	2	3
20-29	20	18105.60		
29-38	53	60684.58	60684.58	
38-47	60		297647.53	297647.53
more than 56	13		319467.38	319467.38
47-56	30			411975.00
Sig.		.993	.079	.786

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 25.537.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 8. Tukey HSD, Knowledge Creation – Homogeneous Subsets

Knowledge creation	N	Subset for alpha = 0.05	
		1	2
9-22	40	77534.10	
23-36	57	113764.02	
51-63	15	274266.07	274266.07
37-50	41	313198.95	313198.95
64-76	23		496022.26
Sig.		0.105	0.146

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 28.236.
b. The group sizes are unequal. The harmonic mean of the group sizes is used.

Table 9. Tukey HSD, Patent Applications by Origin – Homogeneous Subsets

Patent applications by origin	N	Subset for alpha = 0.05		
		1	2	3
15-30	54	65816.80		
1-15	51	95027.16		
30-45	19	234144.26	234144.26	
more than 60	33		463178.24	463178.24
45-60	19			516603.05
Sig.		0.341	0.088	0.976

Table 10. Tukey HSD, PCT International Applications by Origin – Homogeneous Subsets

Tukey HSD[a,b]			
PCT international applications by origin	N	Subset for alpha = 0.05	
		1	2
0-20	80	69016.38	
80-100	18	94839.11	
20-40	26	183696.81	
60-80	25		496560.88
40-60	27		501148.89
Sig.		.722	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 27.240.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 11. Tukey HSD, University/Industry Research Collaboration – Homogeneous Subsets

Tukey HSD[a,b]			
University/industry research collaboration	N	Subset for alpha = 0.05	
		1	2
25-37	18	14227.44	
37-49	44	78232.77	78232.77
73-85	18	268972.83	268972.83
61-73	55		305635.84
49-61	41		307311.10
Sig.		.076	.140

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 28.343.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Determinante ulaganja rizičnog kapitala u Europi: dokazi iz pokazatelja sustava inovacija (2013.–2020.)

Sažetak

Ovaj rad istražuje čimbenike na razini država koji utječu na ulaganja rizičnog kapitala (VCI) u 22 europske ekonomije u razdoblju od 2013. do 2020. godine. Kombiniramo ukupna ulaganja rizičnog kapitala prema podacima Invest Europe s 14 pokazatelja iz Globalnog indeksa inovacija (GII) te svaki pokazatelj svrstamo u kvintile. Korištenjem jednosmjerne analize varijance (ANOVA) s Tukey HSD post-hoc testovima, procjenjujemo razlikuju li se VCI sustavno između pojedinih kvintila za svaki od promatranih pokazatelja. Ulaganja rizičnog kapitala izrazito su koncentrirana: Francuska i Njemačka čine stabilan gornji segment, a slijedi ih Nizozemska, dok su Rumunjska, Bugarska i Grčka pri dnu. Jedanaest od četrnaest pokazatelja pokazuje značajne razlike u razinama VCI između kvintila: poslovno okruženje, učinkovitost javne uprave, bruto izdaci za istraživanje i razvoj, ljudski kapital i istraživanja, pristup IKT-u, korištenje IKT-a, rezultati znanja i tehnologije, stvaranje znanja, prijave patenata, PCT prijave i suradnja između sveučilišta i industrije. Nasuprot tome, pokazatelji poput izvoza kreativnih dobara i usluga, izvoza IKT usluga te političke i operativne stabilnosti ne diferenciraju razine ulaganja rizičnog kapitala unutar europskog uzorka. Rezultati su robusni na alternativne metode grupiranja, log-transformaciju VCI-a te isključenje najvećih investicijskih ekosustava. Dobiveni obrasci interpretiraju se kao dosljedni s koncentracijom VCI-a u zemljama koje imaju visoku institucionalnu kvalitetu, snažne inovacijske inpute, visoku digitalnu spremnost te obilne izlazne rezultate u znanju i intelektualnom vlasništvu. Nalazi pružaju konkretne smjernice za politike usmjerene na jačanje financijskih ekosustava za MSP-ove, uz uvažavanje činjenice da se radi o asocijativnom istraživanju i agregiranim podacima o VCI-ju kroz sve faze i sektore.

Ključne riječi: rizični kapital, inovacija, Globalni indeks inovacija, Evropa, istraživanje i razvoj (I&R), digitalna spremnost, ANOVA