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Geography of Higher Education Institutions (HEIs) and Regional Innovation: Empirical Evidence and Policy Design

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Abstract

This paper aims to assess the contribution of higher education institutions (HEIs) to the innovation performances in EU regions. Empirical evidence shows that HEIs are a necessary but not sufficient component of regional innovation systems, contribute to the performance of their regional community and make regional innovation policies more efficient. Due to the increasing focus on HEIs as drivers of regional innovation, this paper discusses the need for a holistic approach that operates from the perspective of higher education policy that involves removing barriers to collaboration, innovation and entrepreneurship and creates synergies with other policy areas, such as innovation and regional development. We therefore ask (i) how the presence, quality and connectedness of HEIs map onto regional innovation outcomes and (ii) under which conditions their effects are amplified. Using an EU-wide regional dataset (EIS indicators, patents, co-publications, R&D and human capital) we estimate PLSR/PCR models to address multicollinearity and reveal latent drivers. Findings confirm that HEIs raise performance when embedded in strong R&D and policy environments; on their own, effects are limited. We classify regions into practical archetypes (leaders, over-performers, under-performers) to guide place-sensitive strategies. Policy implications include removing collaboration barriers, incentivizing university–industry–public co-creation, and aligning higher education with innovation and regional development through multi-level governance. Robustness checks support the stability of results across specifications.

Keywords: innovation; education; development; R&D; policies; human capital

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1. Introduction

The role of higher education institutions (HEIs) in driving regional innovation is an interesting and rather debated topic in scientific literature. These institutions significantly contribute to the innovative capacity of regions, acting as key nodes in knowledge networks and promoting technology transfer and research commercialisation. Breschi and Lissoni [1] highlighted the role of HEIs in regional knowledge networks, while Acs et al. [2] noted their importance in transforming knowledge into commercial applications through collaboration with local industries. To maximise the impact of HEIs on regional innovation, it is essential to explore ways to enhance these collaborations [3–5].

Evidence indicates that HEIs play a central role in regional innovation systems by providing knowledge, skills, and research outputs. Their collaboration with local busi-

nesses and governments significantly enhances regional innovation capabilities, supporting regional economies by fostering environments conducive to innovation and strategic partnerships. University–industry interaction is important for technology transfer and research commercialisation, highlighting the role of academic institutions in bridging the gap between research and practical application. Policies that promote collaboration between HEIs and regional stakeholders create a more dynamic and efficient innovation ecosystem [6,7].

Etzkowitz et al. [8] discuss the Triple Helix model of university–industry–government relations, which improves communication and cooperation to enhance regional innovation strategies and policies. The effectiveness of HEIs in contributing to regional innovation also depends on their ability to adapt to the specific needs and strengths of their regional economy. Cooke [9] emphasises that HEIs must respond to the changing dynamics of their local context to contribute effectively to economic development.

A holistic approach to higher education policy is essential, intending by holistic policy a comprehensive vision of higher education, it emphasizes the integration of universities with innovation and territorial development [10–12]. Universities are seen not only as places of knowledge transmission but also as key drivers of local growth through research, technology transfer, and advanced skills formation. Such a policy fosters collaboration between universities, enterprises, and institutions, reinforcing the innovation ecosystem. In this perspective, the link with the territory becomes a catalyst for sustainable growth and social cohesion. Higher education policies must align with regional innovation and development policies to optimise the effectiveness of HEIs. Establishing policy relationship between higher education, innovation, and regional development is necessary. This involves creating policies that directly support innovation activities and align educational programs with the skills required by the regional labour market. Co-creating innovation-focused regional development policies can improve the relevance and effectiveness of innovation initiatives, leading to better alignment between educational and regional economic objectives.

Summarising, we can draw two research questions:

1. Can a geography of HEIs be identified, and how does regional diversity within HEIs affect their innovation capacities and contributions to regional development?
2. What factors determine the different impact of HEIs on the regional innovation system?

The paper is organised as follows. The second Section presents a literature review. The third Section discusses the methods, model, and data. The fourth Section presents the results. The fifth Section discusses the results and policy implications. The final Section concludes and identifies possible next steps for the research.

2. Literature Review

Scientific knowledge plays a key role in fostering innovation and promoting economic development, in regions. The capacity to innovate has become essential for maintaining a competitive edge through technological advancements. To set a research agenda, it is necessary to investigate these interrelationships in more detail. Breschi and Lissoni [1] provide a comprehensive critique of the existing literature on localized knowledge spillovers (LKSs), arguing that current econometric evidence lacks a robust theoretical foundation. They suggest that LKSs—often treated as positive externalities—are too limited to account for the various mechanisms through which knowledge can be transmitted, which may be spatially bounded.

Understanding the spatial dynamics of innovation and innovation drivers is particularly relevant when looking at economic growth within the European Union, in which innovation generates a large portion of growth [13–16] and employment [9,17–19].

HEIs have started engaging more with the community in which they are embedded and, in doing that, they interact with a wide range of stakeholders, including customers,

users, and partners who may be located nearby or far away. The external environment may be significantly impacted by these links and exchanges since universities, as amply demonstrated by studies on the subject, have a significant ability to influence local, regional, and national economies and society [20]. While industrial research and development is often focused on commercial goals, the fundamental knowledge generated through university R&D is a crucial input that can be exploited by the private sector for innovative activities and may even encourage private sector R&D, as noted by [21], based on Griliches [22–27] used a knowledge production function to measure the influence of universities on innovative production and discovered a considerable affirmative impact of university R&D on innovative output utilizing business patents at the state-level in the US. The aim was to examine whether the proximity to the source of spillover was advantageous or required to benefit from the spillover effects. For investigating that, he employed the patents produced by corporations assigned to different states over time and relating them to industry research and development over time. The study revealed that, in a period in which large firms with a structured R&D system were collaborating with US universities, there was an impact of university research on these patents at the state level, providing evidence of spillover that was mediated by geographic proximity, after adjusting for industry R&D. In addition, a related hypothesis, which was implied in the Silicon Valley narrative, was also examined, specifically whether university research led to an increase in industry R&D expenditure in nearby locations [28,29]. The reason to go further investigating lies in the fact that also indirect impact of university research is relevant from a regional economic policy perspective: it appeared from the results that university research causes industry R&D. Therefore, a state enhancing HEIs' research system will attract industrial R&D and also impact local innovation by boosting productivity. Building on the evidence that emerged in, Jaffe [21], Acs et al. [2,21] and Feldman [30] discovered an even greater influence of university research on regional innovative output based on data on the number of innovations obtained from the US Small Business Administration.

Moving to Europe, Piergiovanni et al. [31–33] conducted a study to determine the extent to which research and development activities conducted by universities and corporations spills over to small businesses at the regional level. The hypothesis was tested on a panel dataset consisting of the twenty Italian regions and from years 1978 to 1986. The results of the study extended to Italy previous findings by Jaffe [21,34], Acs et al. [21], and Feldman [30]. According to the estimates, there has been shown a positive and statistically significant relationship between R&D spending and total patents across all businesses. The "university research" variable was higher in magnitude for small businesses than the industrial R&D variable, although significant at the same level. In 2001, Piergiovanni and Santarelli, based on Piergiovanni et al. [31], tested the hypothesis that patent activity in each region of France was related to R&D spending by corporations and universities in the same area. The results showed that, in terms of the production function model, university research had a greater impact on innovation for both private and state-owned industrial firms than industrial research. This finding is partly due to the French national innovation system, which facilitates the dissemination of technological knowledge from universities and public research centers to smaller French firms. As a result, these firms tend to rely on university research as their primary source of innovative inputs.

When taking into account spatiality, research has shown that the role of universities in private sector R&D is largely limited to the geographic region where the university is located and so this suggests that space plays a significant role in facilitating knowledge spillovers [35–39]. Anselin, Varga, and Acs [40], augmenting the spillover effects modelling in Jaffe [21], Acs et al. [21] and Feldman [30], determined that in the United States, the

noteworthy impacts of university R&D on the innovative output of private sector firms are restricted to a radius of around 75 miles.

The quantity of scientific publications was used in Autant-Bernard (2001) [41] to conduct research in France and analyze the spatial component of knowledge spillovers from public research. The study demonstrated that the influence of external factors from outside the region on regional innovation output is only marginal at best. Similar findings were made by Beise and Stahl (1999) [42], who found that in Germany, the influence of public research institutes on business innovations is concentrated near the knowledge source. More than half of the businesses that embraced innovative discoveries generated by universities were just 100 km away. And finally, as shown by an innovation study conducted in certain European countries, the majority of universities' private sector collaboration partners are located in close proximity [36,43]. Thus, evidence suggests that academic knowledge tends to be limited by geographic boundaries, which means that the exchange of knowledge between actors located in different regions can be seriously restricted [39,44,45].

As a result, it is crucial to identify the components of an R&D system that serve as the most decisive drivers of innovation and to determine the factors that determine the system's capacity for innovation [46–49].

The Triple Helix model explicates how industry, academia, and the state interact in an evolving manner, enabling new innovative combinations [8,50]. Inside this framework, HEIs play a crucial role by generating the knowledge, skills, and innovations essential for advancing local, regional, and national economies toward sustainable growth [51–53]; the industrial sector, consisting in SMEs, large corporations, as well as foreign owned and R&D-focused companies, exploits this generated knowledge to transform scientific discoveries into marketable goods; government plays a crucial role by providing regulatory frameworks and financial support, thus creating an enabling environment for collaboration [52]. The interactions among these agents are characterized by communications, robust network structures, and strategic alliances [8].

Evidence shows that robust connections between HEIs, industry, and the government generate collective advantages and enhance economic conditions and industrial competitiveness [54,55].

Policymakers belonging to a variety of sectors and different government levels, ranging from supranational to local governments, are mobilised to leverage HEIs and determine talent, innovation, and sustainability, based on their policy perspectives. The emerging priorities of higher education include the establishment of new evaluation frameworks that aim to reorganise resources, careers, and incentives to unleash the potential of faculty, staff and students to generate societal value for their communities and networks [56–58].

In most cases, in responding to the existing incentives established by higher education policy frameworks [57,58], leaders of HEIs do not consider innovation as a strategic priority of the institution. Thus, often the HEI does not have specific resources or incentives to engage with external stakeholders, and this is especially true for HEIs that help students specialise in humanities and social sciences. Hence, the narrative that HEIs can become drivers of innovation and regional development in their own communities is restrained by the problematic alignment of various policy objectives, which generate trade-offs between them.

In sight of the evidence emerged on the importance of the territory in which actors are embedded, we need to introduce "geography", which refers to a spatial approach in higher education: a holistic policy agenda is then mandatory to connect different policy sectors to promote entrepreneurship, innovation, and research. A strong finding to support the need for complementarities when implementing innovation policies is offered by Mohnen and Roller [59]. By developing a framework for evaluating innovation policies synergies

and putting it into practice using data generated by Community Innovation Survey 1 and focusing the analysis on Denmark, Germany, Ireland and Italy, they concluded that the presence of synergistic effects in innovation policies is influenced by the stage of innovation, whether it's about the likelihood or the depth of innovation, and the specific combination of economic policies. Otherwise, the evidence concerning the likelihood of innovation suggests various instances of complementary connections within innovation policy.

Recent studies have placed greater emphasis on the role of higher education institutions as drivers of innovation and growth in specific regions. These studies demonstrate how universities influence local and regional development by producing knowledge, fostering entrepreneurship, and developing human capital. Peng and Xu [60] demonstrate that universities generate urban spillovers in innovation and entrepreneurship, though their effects are strongly region-specific. They base this on evidence from 239 Chinese cities. Wang [61] has revisited four decades of scholarship linking education, innovation and economic growth. The author argues that while the connection is robust, sustained benefits require targeted policies and adaptive governance. The conceptual understanding of universities has also evolved. Dunbar [62] highlights how universities are increasingly viewed as innovation hubs rather than merely educational institutions. However, the translation of research into economic outcomes remains uneven. Fehder, Hausman, Hochberg and Lee [63] show that the commercialisation of university-based research depends heavily on location, with urban universities enjoying advantages due to their access to finance and denser entrepreneurial ecosystems. Outside of large metropolitan areas, universities also play a vital role in smaller cities. Osutei and Kim (2023) [15] reveal that they help such places to attract and retain talent, thereby mitigating brain drain and contributing to regional resilience. The literature review highlights several insights into the relationship between higher education institutions (HEIs), innovation, and geography, but also points to significant gaps. Although there is a broad emphasis on localised knowledge spillovers (LKSs) and the role of geographic proximity in fostering innovation, most studies predominantly focus on measurable impacts (such as patents or R&D expenditures), neglecting the qualitative mechanisms that underlie knowledge transfer in geographically and institutionally diverse contexts. There is also a lack of integration between the spatial dynamics of innovation and the governance and public policy frameworks that shape the ability of HEIs to foster innovation at regional scales. The literature has extensively documented the role of universities in generating knowledge spillovers and fostering regional innovation, existing studies are mainly focused on quantitative measures (patents, R&D expenditures, publications), while neglecting the qualitative mechanisms through which these effects unfold across different geographical and institutional contexts. Furthermore, the interaction between these spatial dynamics and non-spatial factors—such as synergies between policies or institutional incentives—remains poorly explored. Finally, although the Triple Helix model emphasises the strategic interplay between government, industry, and academia, further insights are needed into how this model operates in different regional innovation systems, especially under varying socio-economic and political conditions. This highlights the need for a more holistic framework that integrates geography, governance, and interdisciplinary approaches to fully understand and enhance the role of HEIs in innovation ecosystems Within this framework, the paper's contribution to the literature is to highlight the complex interactions among policies in the real-world scenario to understand the way in which different dimensions form linkages with HEIs. It further aims to assess how regional innovation systems generate complementarities that can be "latent" and need to be encouraged by specific governance arrangements involving different policy areas, levels of government and stakeholders.

3. Methods and Data

Partial least squares regression (PLSR) is a statistical method used to analyse the relationships between a dependent variable and a set of independent variables. It is a useful technique while working with several interrelated independent variables. PLSR is a fast, efficient, and optimal regression method based on covariance. It is recommended to be used in regression cases where the number of explanatory variables is large and multicollinearity between the variables is likely. PLSR attempts to create new independent variables, known as latent components, which capture the maximum variance in the dependent variable and sets of independent variables. These latent components are created in such a way as to maximise the covariance between the independent variables and the dependent variable. The goal is to obtain latent components that provide an accurate and parsimonious explanation of the data. PLSR is particularly suitable when working with high-dimensional data or data with correlation problems between the independent variables. So, Partial Least Squares Regression (PLSR) was selected as the primary method due to the high dimensionality of the dataset and the strong multicollinearity among variables and because this model allows for a more robust identification of hidden structures and interrelationships. This makes it particularly suitable for capturing the complexity of regional innovation systems, where multiple interdependent factors jointly explain performance.

The PLSR process involves the creation of latent components through a linear combination of the original independent variables. These latent components are selected to maximise the variance explained in the dependent variable, iterating the process until the variance reaches the maximum value, or the specified number of latent components is reached. Once the latent components are obtained, they can be used to construct a partial regression model that provides predictive estimates for new data. PLSR can also be used to perform principal component analysis, which allows one to identify the independent variables that contribute most to the variability of the dependent variable. The goal is to obtain latent components that provide an accurate and parsimonious explanation of the dataTo interpret the results of partial least squares regression (PLSR), it is important to consider several aspects: (1) Variable Importance: Higher regression coefficients indicate more significant contributions to prediction, (2) Latent Components: Weights in components reveal key contributing variables and underlying patterns, (3) R-square (R^2): Measures dependent variable variance explained by the model, (4) RMSE: Reflects model prediction accuracy, (5) Q2: Cross-validation performance indicator, and (6) Correlation coefficient (r): Assesses model fit.

Principal Component Regression (PCR) is a regression method used to address multicollinearity problems between the independent variables in a linear regression model. This approach combines Principal Component Analysis (PCA) and linear regression. PCR proceeds in several steps: (1) Principal component analysis is performed on the independent variables to obtain the principal components ordered by importance, (2) an appropriate number of principal components is selected for use in the regression model. This selection can be based on the percentage of variance explained or by statistical criteria such as Akaike's information criterion (AIC) or Bayesian information criterion (BIC), (3) the selected principal components are used as predictors in the linear regression model, together with the dependent variable, and (4) linear regression is performed using the principal components as independent variables to estimate the regression coefficients.

PCA is a dimensionality reduction technique that transforms a set of correlated variables into a new set of uncorrelated variables, known as principal components. Principal components are linear combinations of the original variables and are ordered according to their variance. Hence, the first principal component explains the maximum variance of the data, the second component explains the maximum residual variance, and so on for

remaining components. In the context of PCR, PCA is applied to the independent variables to identify the principal components that explain most of the overall variance in the data. Subsequently, these principal components are used as new independent variables in the linear regression model. PCR offers several advantages, including effectively handling the multicollinearity problem, reducing the dimensionality of the data, and simplifying the interpretation of the results. The components obtained from the PLS regression, which is based on covariance, are constructed to explain Y as best as possible, whereas the components from the PCR are constructed to describe X as best as possible. This explains why PLS regression outperforms PCR when the target is strongly correlated with a direction in data with low variance.

To capture the complexity and interrelationships among the variables, a PSLR model and a PCR model will be used. The PLSR model is particularly effective when the independent variables are highly collinear. This model reduces the dimensionality of the dataset by constructing new latent variables that are linear combinations of the originals. PLSR reduces the dimensionality of the data while preserving most of the variability present in the predictors, improving interpretability and computational efficiency. In addition, PLSR maximizes the variance explained in both the predictors and the response variable, making it more effective in finding meaningful relationships between variables due to its ability to model complex linear relationships.

The PCR model, on the other hand, is simpler to interpret than other multivariate methods. Principal components are sorted by the amount of variance explained, making it easier to identify the most relevant components. PCR helps reduce noise in the data by removing components that explain little variance. This leads to more robust and generalizable models. Like PLSR, PCR also effectively addresses multicollinearity among predictors, improving the stability of regression coefficient estimates (see Appendix A for more details).

To conduct econometric analyses, it is necessary to build a database that considers as much as possible all those aspects that link HEIs with the spatial dimension and innovation. A geographical basis of European regions intermediate between Nuts 1 and Nuts 2 was chosen for the construction of this database, which contains variables derived from different sources and referring to different spatial levels [64–70]. This definition of the regional scale is intermediate between Nuts 1 and Nuts 2 because it is considered that the Nuts 1 level is too aggregated to describe these phenomena, whereas the Nuts 2 level is too disaggregated for the purpose of the analysis. Also, since the data originated from different sources using different classifications of regions, a process of data homogenisation was necessary. After removing the countries for with no regional data for a significant number of indicators, the final formulation of the database consisted of a set of 23 indicators for 168 regions for the year 2021, which is the most recent year of updating the 23 variables. The regional scale with 168 regions guaranteed a good spatial variability of the indicators, reducing the risk of excessive autocorrelation. The database consisted of the 23 indicators as shown in Table 1.

Table 1. Indicators utilised for analysis.

	Indicators Name	**Source**
1.	Population with tertiary education	Eurostat
2.	Lifelong learning	Eurostat
3.	International scientific co-publications	Scopus/Eurostat

Table 1. *Cont.*

Indicators Name		Source
4.	Most-cited publications	Scopus
5.	Digital skills	Eurostat
6.	R&D expenditures public sector	Eurostat
7.	R&D expenditures business sector	Eurostat
8.	Non-R&D innovation expenditures	Eurostat
9.	Innovation expenditures per person employed	Eurostat
10.	IT specialists	Eurostat
11.	Product process innovators	Eurostat
12.	Business process innovators	Eurostat
13.	Innovative SMEs collaborating with others	Eurostat
14.	Public–private co-publications	Scopus
15.	PCT patent applications	OECD/Eurostat
16.	Trademark applications	EUIPO
17.	Design applications	EUIPO
18.	Employment knowledge-intensive activities	Eurostat
19.	Employment in innovative SMEs	Eurostat
20.	Sales of new-to-market and new-to-firm innovations	Eurostat
21.	No. of Universities	Eurostat
22.	Total Academic Personnel (FTE)	Eurostat
23.	European Innovation Scoreboard (EIS)	European Commission

4. Results

4.1. Partial Least Squares Regression Results

The previous section highlighted the reasons and advantages of using the PLSR methodology to highlight the complex interactions among policies in the real world and understand how the interrelations between policies can be hidden and need to be encouraged by specific governance. The results of the empirical analyses enable the demonstration of a few good indications in this respect. The robustness of the results is emphasised by the indicators of goodness of fit that are given in the Appendix A. In the context of PLSR models, the analysis scheme envisages the use of a traditional PLSR model to define the interrelationships between the variables. The output of this model will be a principal component analysis of the 23 variables and a PCR model for studying the classification of the different European regions.

The PLSR and PCR models help in measuring these interrelationships while also revealing the latent structure existing between the variables to explain the differences in the degree of innovation between European regions based on these considerations.

In the Appendix A, all Fit Goodness-of-Fit indicators of the first PLSR model are reported, which denote a level of robustness of the estimates.

The first analysis aims to mainly measure the contribution of each variable to explain the regional European Innovation Scoreboard. To order to make the measurement, it is necessary to examine the p-vectors that are derived from the estimation of the model and are shown in Table 2.

Table 2. P-vectors.

Variable	p1
Population with tertiary education	0.126
Lifelong learning	0.222
International scientific co-publications	0.271
Most-cited publications	0.228
Digital skills	0.215
R&D expenditures public sector	0.237
R&D expenditures business sector	0.260
Non-R&D innovation expenditures	0.011
Innovation expenditures per person employed	0.220
IT specialists	0.225
Product process innovators	0.236
Business process innovators	0.231
Innovative SMEs collaborating with others	0.228
Public–private co-publications	0.293
PCT patent applications	0.280
Trademark applications	0.220
Design applications	0.139
Employment knowledge-intensive activities	0.189
Employment in innovative SMEs	0.253
Sales of new-to-market and new-to-firm innovations	0.145
No. of Universities	0.114
Total Academic Personnel (FTE)	0.128

In graphical form, the level of importance of each variable is even more distinct. Therefore, as can be seen in Figure 1, all variables contribute significantly to the explanation of the dependent variable except for the variable "Non-R&D Innovation". These considerations are further reinforced by the analysis of VIP (Variable Importance in the Projection) and VID (Variable Importance in the Projection for Interaction).

In the context of the PLS regression, VIP and VID are measures used to assess the importance of the independent variables in the model.

1. VIP (Variable Importance in the Projection): It assesses the importance of each independent variable in the PLS model considering both the effect of the variable on the dependent variables and the structure of the independent variables themselves. Higher values of VIP indicate a higher importance of the variable in the model. The VIP is calculated as the sum of the explained deviations (R^2Y) for all principal components of the model, weighted by the importance of the components (see Appendix A for values).
2. VID (Variable Importance in the Projection for Interaction): It is an extension of the VIP that considers the interactions between the independent variables in the PLS model. The VID assesses the importance of variables, both individually and in combination with other variables in the context of interactions. Higher values of VID indicate a higher importance of the variable in the model.

As can be seen from the data presented in Table 3 and Figure 2, all variables with the exception of Non-R&D innovation expenditures depict good explanatory power.

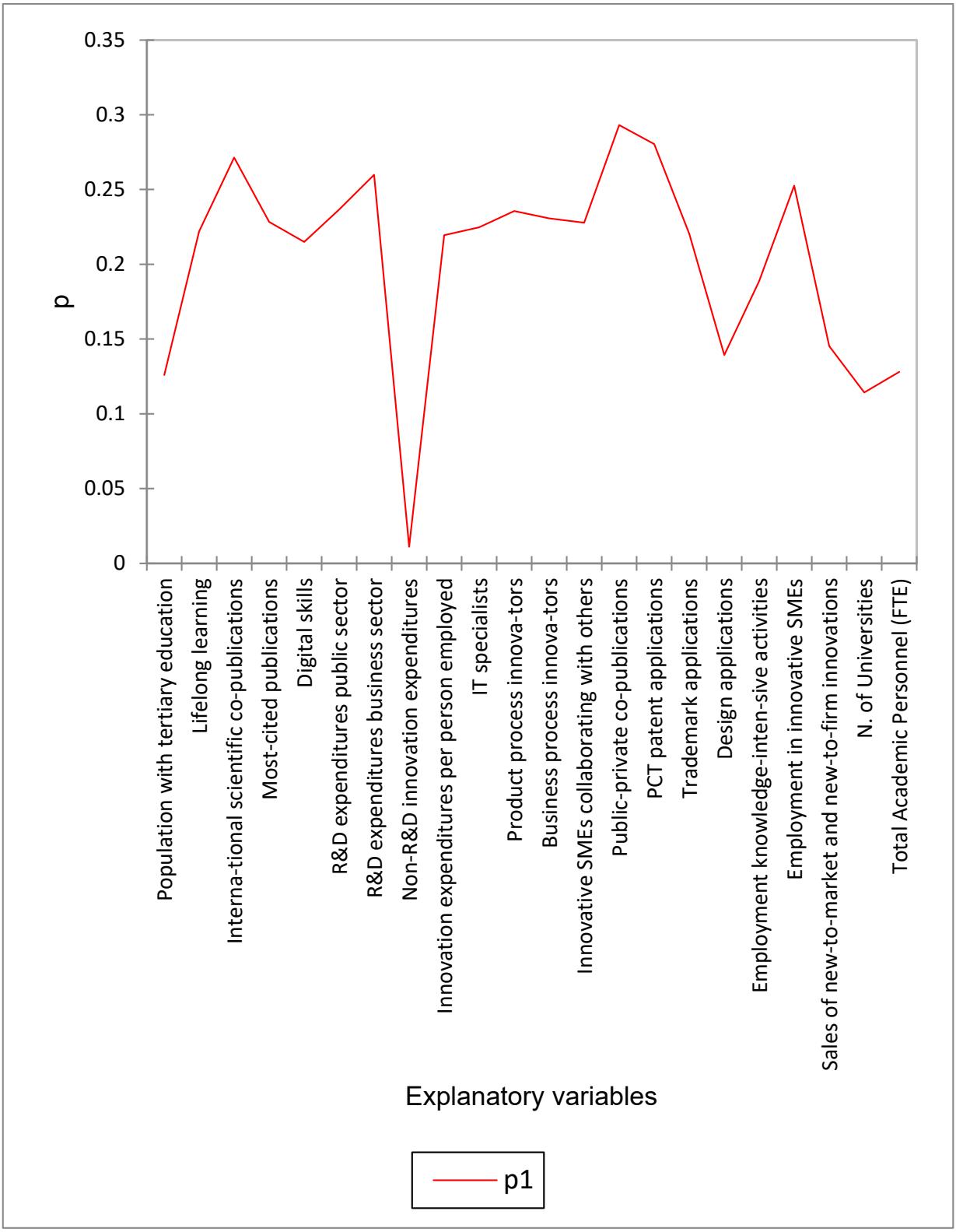


Figure 1. Line loading plot.

Table 3. Standardised coefficients (Variable EIS).

Variable	Coefficient	Std. Deviation	Lower Bound (95%)	Upper Bound (95%)
Population with tertiary education	0.043	0.007	0.026	0.059
Lifelong learning	0.081	0.005	0.068	0.093
International scientific co-publications	0.087	0.006	0.075	0.100
Most-cited publications	0.078	0.006	0.065	0.091
Digital skills	0.079	0.003	0.072	0.087
R&D expenditures public sector	0.078	0.005	0.066	0.090
R&D expenditures business sector	0.088	0.004	0.080	0.096
Non-R&D innovation expenditures	0.003	0.006	−0.011	0.016
Innovation expenditures per person employed	0.072	0.004	0.063	0.081
IT specialists	0.076	0.006	0.063	0.089
Product process innovators	0.073	0.005	0.061	0.085
Business process innovators	0.072	0.004	0.064	0.081
Innovative SMEs collaborating with others	0.073	0.005	0.062	0.084
Public–private co-publications	0.095	0.004	0.086	0.105
PCT patent applications	0.097	0.002	0.092	0.101
Trademark applications	0.071	0.006	0.058	0.085
Design applications	0.046	0.005	0.034	0.058
Employment knowledge-intensive activities	0.063	0.005	0.052	0.074
Employment in innovative SMEs	0.080	0.003	0.073	0.086
Sales of new-to-market and new-to-firm innovations	0.042	0.006	0.029	0.054
N. of Universities	0.035	0.009	0.015	0.055
Total Academic Personnel (FTE)	0.040	0.007	0.025	0.055

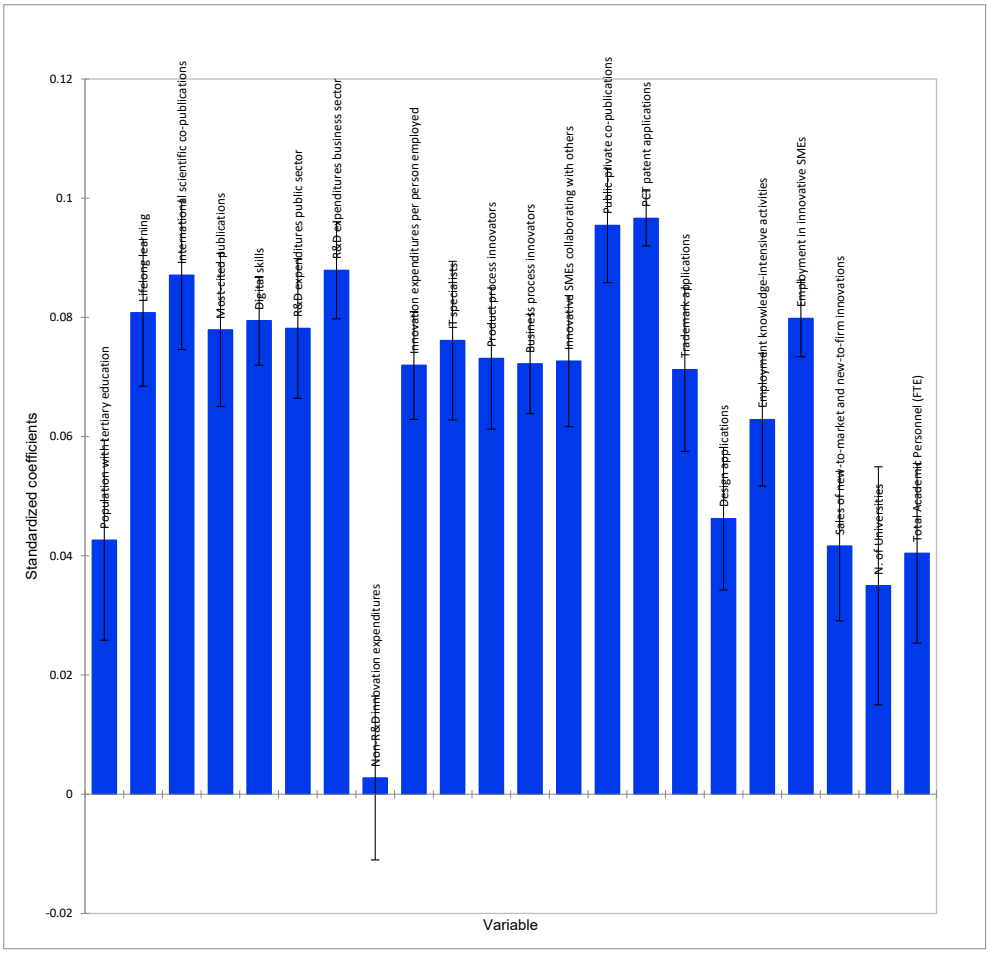


Figure 2. EIS/Standardised coefficients (95% confidence interval).

The PLSR model works well in the presence of series that may present multicollinearity and non-heteroscedasticity problems. Figures 3 and 4 show that the condition of homoscedasticity of the data appears to be fulfilled. Homoscedasticity occurs when the residuals are uniformly distributed around the zero line with no obvious pattern.

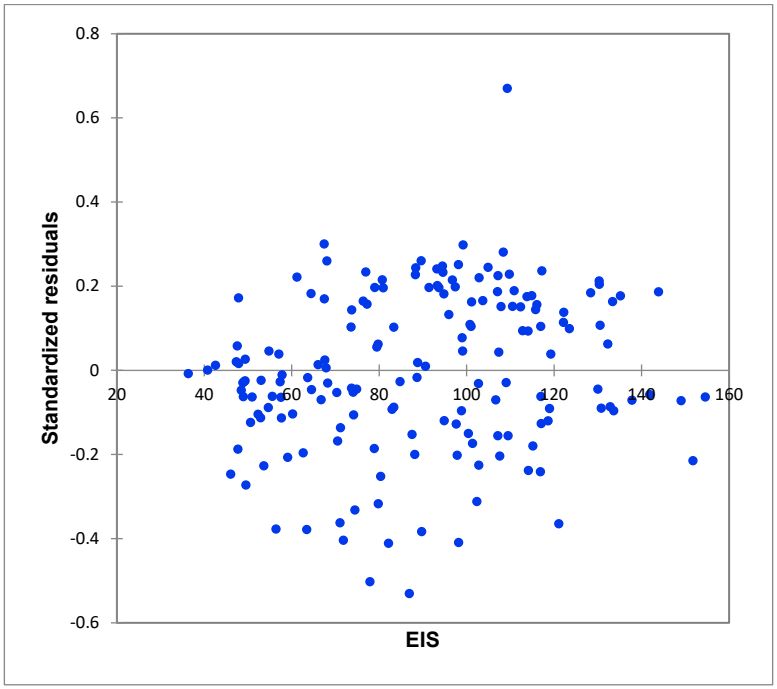


Figure 3. EIS/Standardised residuals.

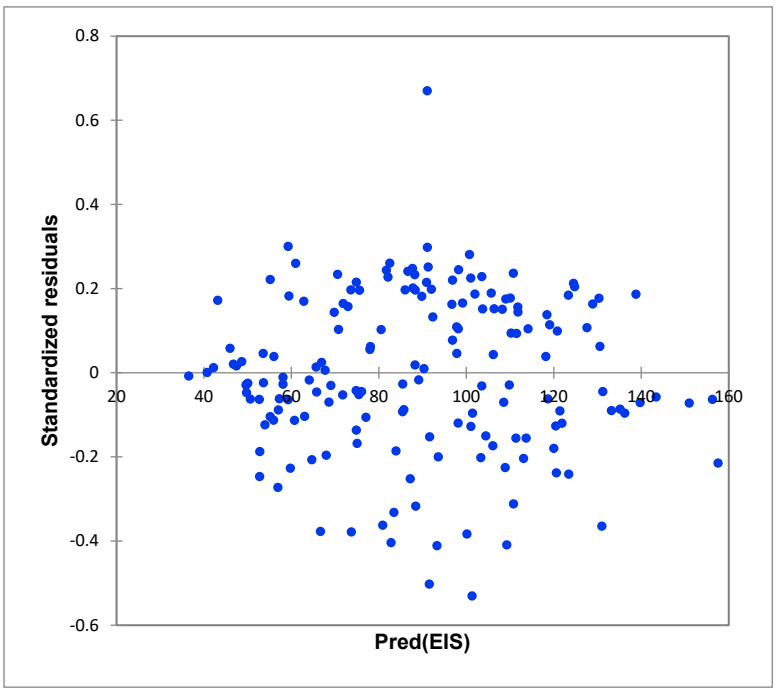


Figure 4. Pred(EIS)/Standardised residuals.

Figure 5 demonstrates the goodness of estimates with almost all values falling within the confidence interval with only three outliers. Overall, the model estimates appear to be convincing.

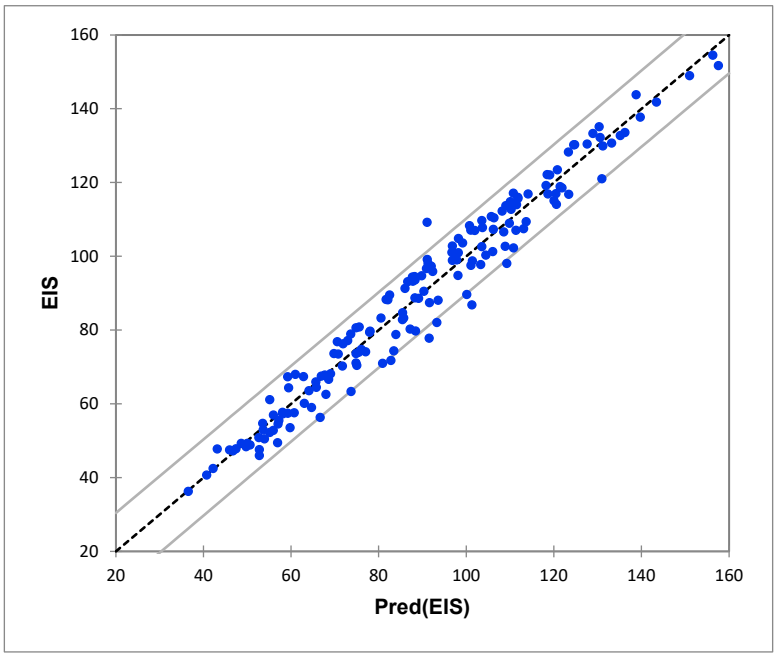


Figure 5. Pred(EIS)/EIS.

4.2. Principal Component Regression Results

The combination of PCR and PLSR can be useful while dealing with complex problems where it is necessary to reduce the dimensionality of the data and consider the relationships between the principal components and the original explanatory variables. However, it is essential to pay attention to the interpretation of the results, as the relationships between the principal components and the original variables can be complex. In a combination of the two techniques, an analysis involving PLS can be used to identify relevant latent components before utilising PCR with the help of these principal components as explanatory variables to model the dependent variable. This can be useful to address complex problems with a high number of variables and multicollinearity.

Table 4 and Figure 6 show that the first two factors explain 54.87% of the EIS, while the contribution of the subsequent factors gradually becomes residual. Studying the spatial dynamics of the EIS with respect to these two factors provides us with a good degree of reliability.

Table 4. Principal component analysis eigenvalues.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22
Eigenvalue	8.84	3.24	1.88	1.25	1.08	0.94	0.79	0.75	0.53	0.46	0.39	0.36	0.29	0.28	0.23	0.18	0.16	0.13	0.09	0.064	0.05	0.03
Variability (%)	40.17	14.71	8.54	5.69	4.92	4.28	3.58	3.41	2.41	2.10	1.75	1.65	1.34	1.25	1.03	0.80	0.73	0.59	0.43	0.29	0.21	0.13
Cumulative %	40.17	54.87	63.41	69.11	74.03	78.30	81.88	85.29	87.70	89.80	91.55	93.20	94.54	95.79	96.82	97.62	98.35	98.94	99.37	99.66	99.87	100.000

The factor loadings in principal component regression (PCR) are the coefficients indicating the relationship between the original variables and the principal components. The factor loads, or loadings, represent the weights assigned to the principal components in the regression. Each original variable is multiplied by its corresponding factor load to calculate the contribution of the principal component in predicting the value of the dependent variable. Factor loads can be used to assess the relative importance of the original variables in predicting the model. They do not directly represent the importance of the original variables in the model; rather, they depict their relationship to the principal components. To interpret the importance of the original variables, it is necessary to consider both factor loads and the variance explained by the principal components. In interpreting

the factor loadings, the sign and absolute value must be considered other than the explained variance, which was found to be 54.89%. Specifically, it must be noted that the first factor presents positive values for all variables with absolute values that are quite relevant for all variables with the exclusion of the "Non-R&D innovation expenditures" pathway.

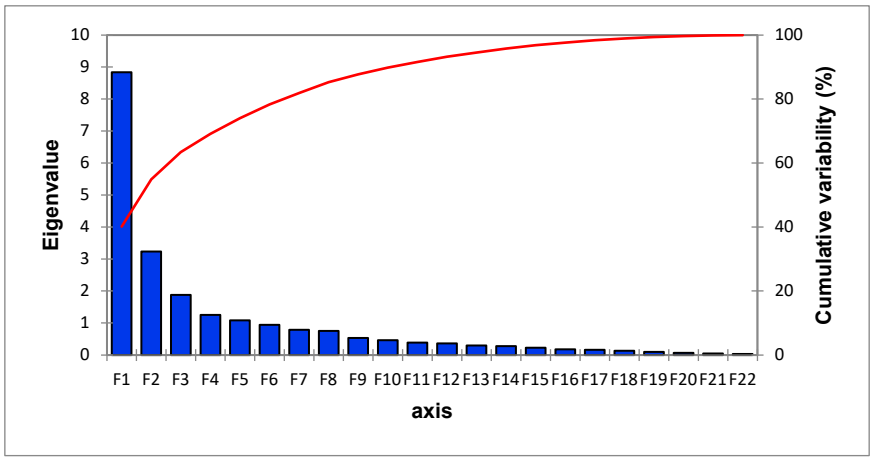


Figure 6. Variability explained by each factor (red line).

The second factor appears to reflect the private sector's focus on research and development, as well as the international orientation of scientific activities. Indicators such as "Population with tertiary education", "Most-cited publications", and "PCT patent applications" have negative values on this factor, while indicators such as "Non-R&D innovation expenditures", and "Business process innovators" show positive values. The first factor, on the other hand, encompasses elements that foster innovation and delineates how individual variables contribute to the overall innovation process. It can be seen as a gauge of a region's overarching ability to generate innovation. The second factor revolves around the degree of public funding allocated to innovation. Increased public funding can help stimulate innovation within businesses, encouraging collaboration and the formulation of novel business approaches. Concurrently, this could potentially have adverse effects on indicators associated with higher education and research, as resources might be diverted elsewhere. The most innovative regions depict positive values of the first factor, whereas the least innovative regions possess negative values. Furthermore, regions with positive values of the second factor show great availability of funding for innovation at the enterprise level but with less attention to other innovation-related variables such as the Higher Education System and Human Capital, while those with negative values show the marginal regions. Taking Mohnen et al.'s [59] definition, it appears from the analysis of these data that Higher Education System and Human Capital, and Research and Development are complementary policies, whereas financial incentive policies for business innovation are imperfect substitutes. The factor loads described in Table 5 are represented graphically in Figure 7.

Figure 7 identifies the interrelationships and links between the 22 explanatory variables in order to identify from a descriptive point of view similarities that allow them to be aggregated into smaller groups.

In general, from the study of correlations, three groups of variables determine the European Innovation Scoreboard (EIS), which provides a comparative analysis of innovation performance in the EU countries. The groups of variables are as follows:

a Research and Development Expenditure
b Innovation Policies
c Higher Education System and Human Capital

Table 5. Factor loadings.

	F1	F2
Population with tertiary education	0.362	−0.523
Lifelong learning	0.640	−0.253
International scientific co-publications	0.805	−0.114
Most-cited publications	0.677	0.187
Digital skills	0.618	−0.313
R&D expenditures public sector	0.703	0.037
R&D expenditures business sector	0.763	−0.302
Non-R&D innovation expenditures	0.054	0.707
Innovation expenditures per person employed	0.660	0.267
IT specialists	0.658	−0.439
Product process innovators	0.715	0.515
Business process innovators	0.704	0.614
Innovative SMEs collaborating with others	0.687	0.417
Public–private co-publications	0.869	−0.119
PCT patent applications	0.823	−0.147
Trademark applications	0.650	−0.298
Design applications	0.409	−0.331
Employment knowledge-intensive activities	0.556	−0.329
Employment in innovative SMEs	0.764	0.488
Sales of new-to-market and new-to-firm innovations	0.451	0.589
No. of Universities	0.343	−0.263
Total Academic Personnel (FTE)	0.381	−0.288

Table 6 illustrates how the variables are aggregated. Some variables appear in more than one group, which is a sign of the strong interrelationship that exists between these variables. An interrelationship makes it necessary to postulate the need to harmonise the policies in order to achieve greater efficiency and effectiveness of interventions.

Table 6. Variable aggregation.

Research and Development Expenditure	Innovation Policies	Higher Education System and Human Capital
• Most-cited publications • PCT patent applications • R&D expenditures public sector • Innovation expenditures per person employed • International scientific co-publications • Public–private co-publications	• Sales of new-to-market and new-to-firm innovations • Business process innovators • Innovative SMEs collaborating with others • Product process innovators • Employment in innovative SMEs	• Lifelong learning • IT specialists • No. of universities • Total academic personnel (FTE) • Digital skills • Employment knowledge-intensive activities • Trademark applications • R&D expenditures business sector • Design applications

The following variables remain out of this scheme: “Non-R&D innovation expenditures” and “Population with tertiary education”.

Figure 8 allows the variables to be positioned with respect to the first two axes. On the basis of these indications, an interpretation can be provided for the two factors (See Appendix A for the value of each region).

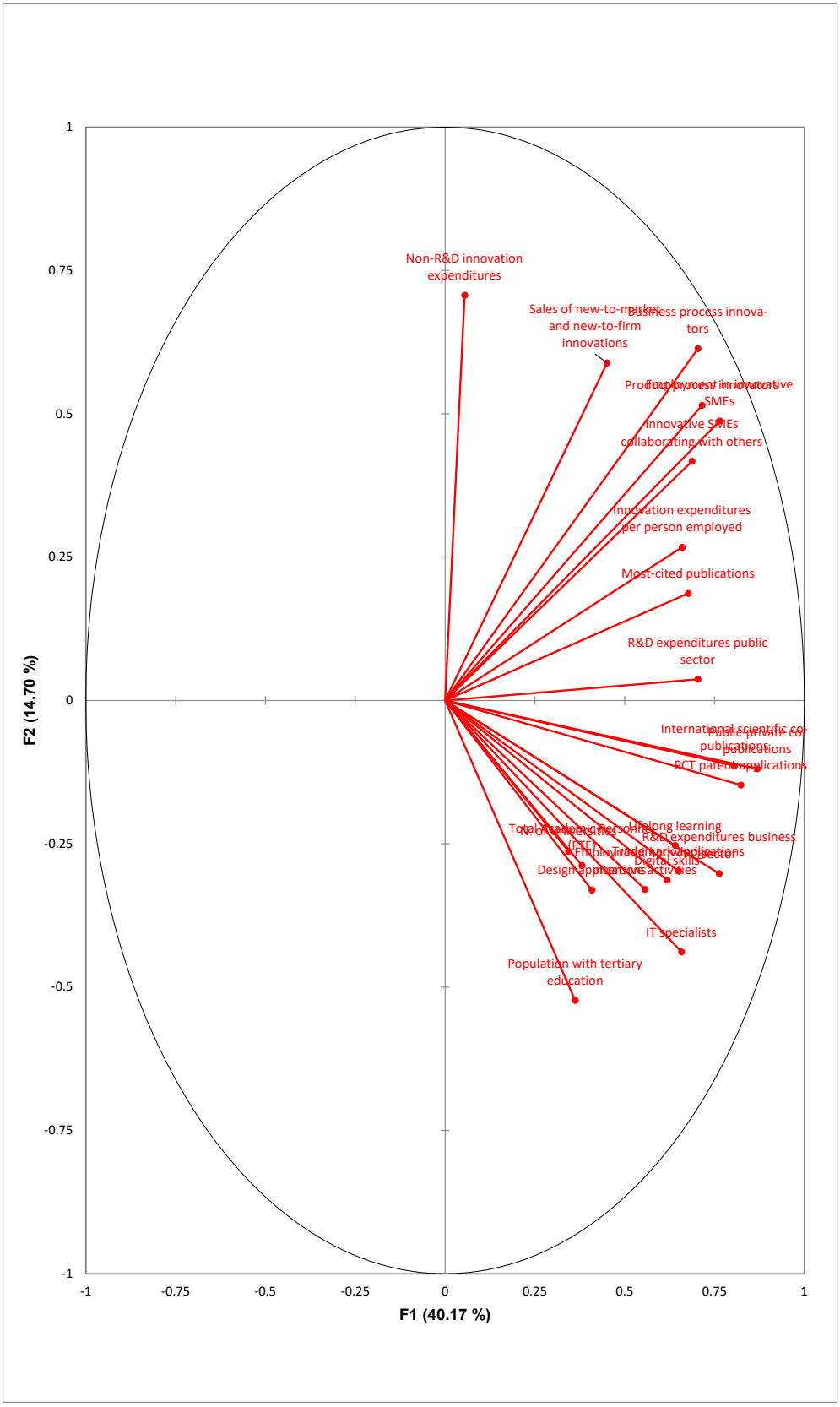


Figure 7. Variables (Axes F1 and F2: 54.87%).

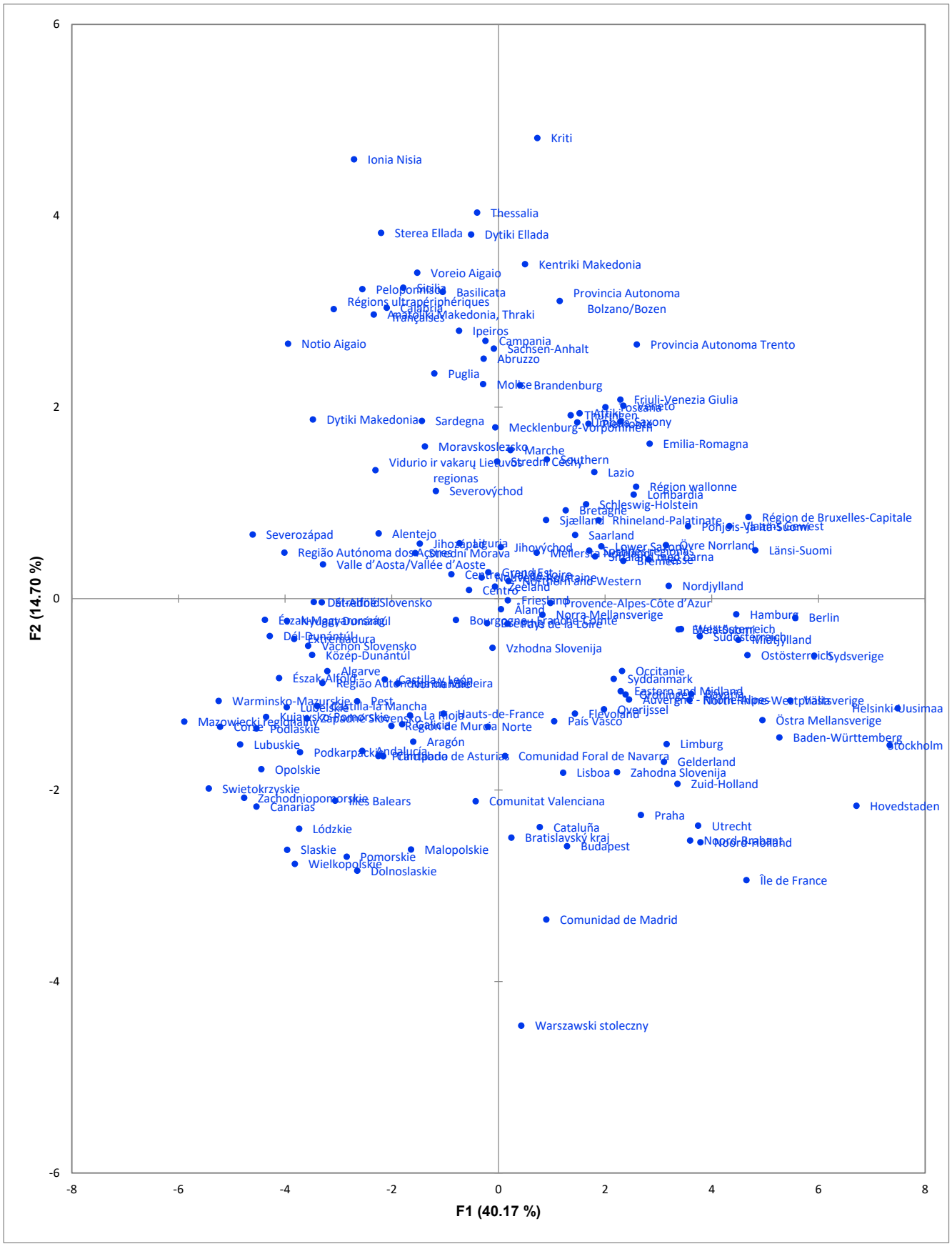


Figure 8. Region value for two axes (Axes F1 and F2: 54.87%).

Figure 8 represents the geography of higher education in European regions, i.e., the way in which HEIs contribute to the innovation performance of their own regions. This result can be interpreted by summarising it in Table 7, in which we use the definitions of the Boston Consulting Group matrix for simplicity. Obviously, this result is only intuitive and aims to make the classification that emerges from Figure 8 more understandable. The four quadrants of Figure 8 represent four different regional stages of innovation, which are driven by the HEIs. In Table 7, these can be distinguished in: "Star" regions, i.e., those leading in terms of innovation; and "Dog" regions, i.e., those that are poorly innovative. The two other categories of regions are the "Over-performers" and the "Under-performers", which are in a state of transition that can evolve toward the Star region but also plummet to the Dog region. Star regions are those that have an economic system capable of creating innovation and have great availability of financing for businesses. Over-performant regions have an economic system capable of creating innovation but have less availability of financing for enterprises. The Under-performant regions have good availability of resources for the private sector but fail to perform well in terms of innovation creation. Lastly, the Dog region does not have innovation capacity or availability of resources for enterprises.

Table 7. Regional Innovation Capability Matrix.

	Capability of Economic System of Creating Innovation		
		HIGH	**LOW**
Availability of financing for enterprises	HIGH	STAR	UNDER-PERFORMANT
	LOW	OVER-PERFORMANT	DOG

The next step is to estimate the parameters of the regression model and, as can be seen from the table, the regression coefficients almost always have a high degree of significance:

Based on these estimates, the model appears robust. The PCR model functions well in the presence of series that may present multicollinearity and non-heteroscedasticity problems. Figures 9 and 10 demonstrate that the data's homoscedasticity condition appears to be fulfilled. Homoscedasticity occurs when the residuals are uniformly distributed around the zero line with no obvious pattern.

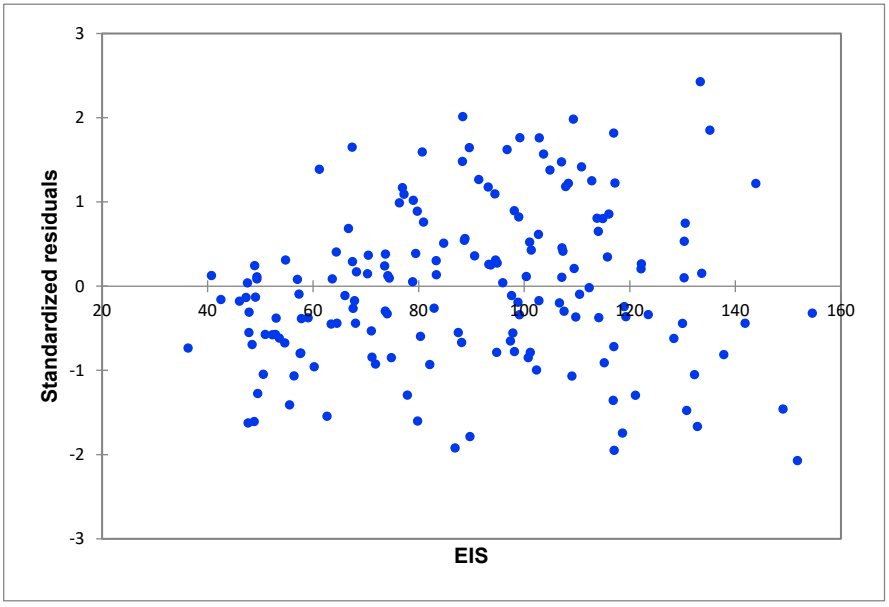


Figure 9. EIS/Standardised residuals.

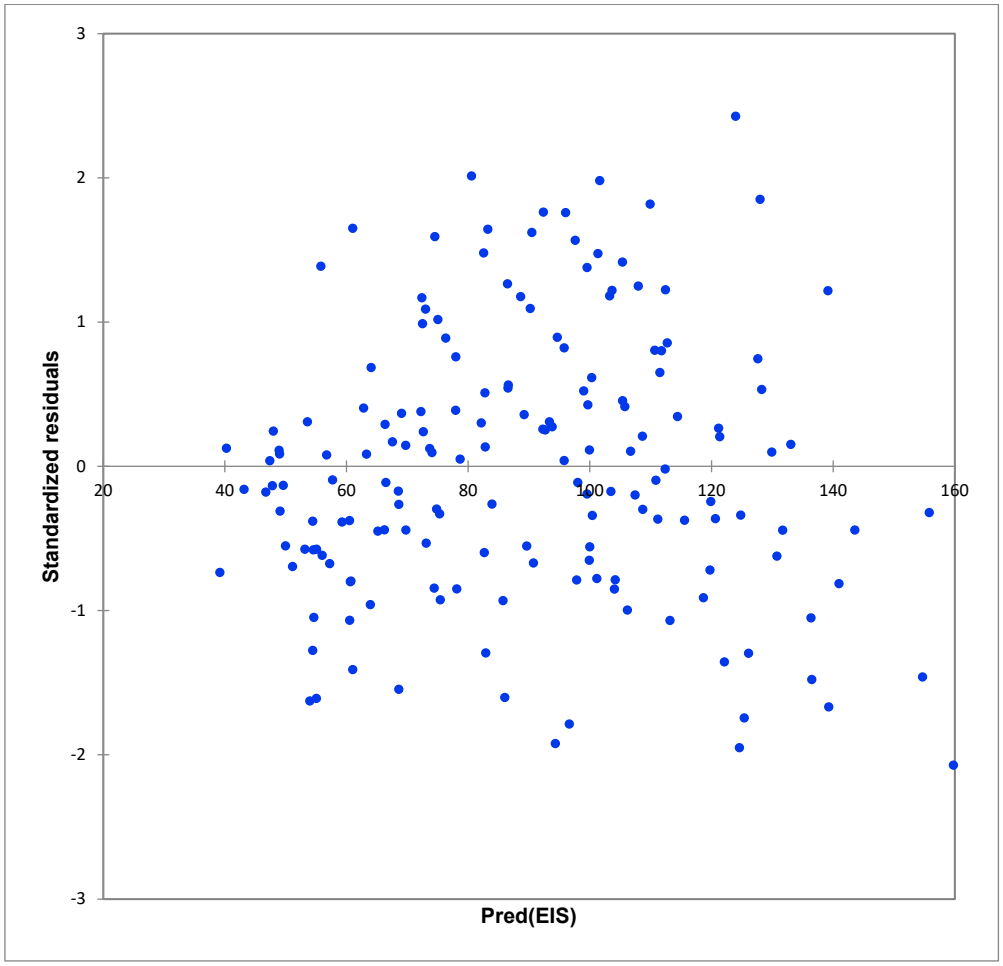


Figure 10. Pred(EIS)/Standardised residuals.

Figure 11 depicts the goodness of estimates with almost all values falling within the confidence interval with only one outlier.

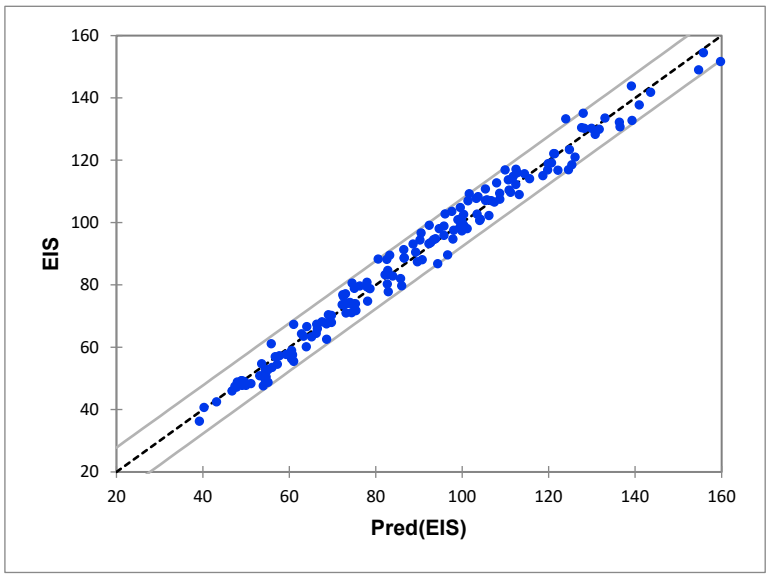


Figure 11. Pred(EIS)/EIS.

The estimates appear to be quite convincing, and a further check can be conducted through the Cook's distance. In general, if the Cook's distance is low for all data points, it

means that no points significantly impact the model, and the analysis can be considered reliable. If, on the other hand, some points have a high Cook's distance, they may need to be examined closely to determine whether they are indeed influential or if problems exist within the model. Figure 12 shows the results for this study's dataset, which are, in almost all cases, very low.

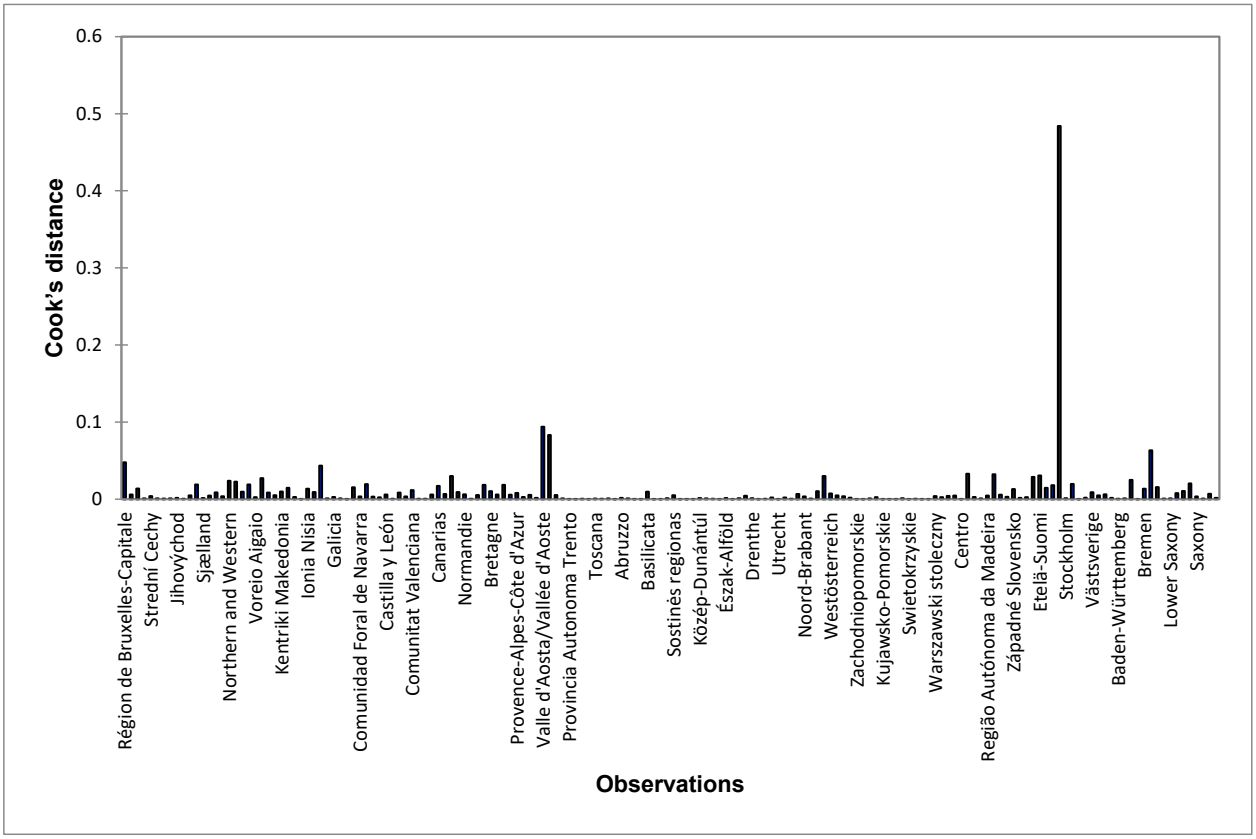


Figure 12. Cook's distances.

5. Discussion

The aim of the empirical investigation was to assess the relationship between higher education and innovation on a territorial basis, also analysing the factors that determine the different impact of HEIs on the regional innovation system. As seen in Section 2, the literature gap is tied to a limited understanding of the qualitative mechanisms underpinning knowledge transfer in geographically and institutionally diverse contexts. The model's results provide insights that can help integrate spatial dynamics, governance, and interdisciplinary approaches, thereby offering a clearer understanding of the role of HEIs in innovation systems.

The objective was to delve into the internal workings of regional development to identify its determinants and understand whether higher education-related variables hold significance in explaining the innovation performance of different regions. More precisely, it is required to verify whether there is a geography of higher education that at least partly the geography of innovation.

The group of correlated variables related to higher education individually have VIDs that signal their importance in explaining the geography of innovation. The PLS model has, therefore, made it possible to identify a latent structure of explanatory variables. The data clarified that all three groups of variables jointly explain the geography of innovation as expected of a phenomenon that is complex in nature. Three groups of determinants

were found to have comparable levels of importance in explaining the phenomenon. Thus, regional innovation performances cannot be explained unless the three groups of variables are considered in conjunction. Neglecting one of them would imply losing a substantial part of the explanatory capacity. The corollary of this statement is that policies are also complex, and to be truly effective, they must consider the interactions, which are the muted interrelationships that develop at the spatial level among the three groups of variables [71–73].

It was found that the geography of Higher Education correlates with innovation; however, this alone is not enough to explain the regional variability of innovation as it can only be examined by delving into the determinants and analysing the interrelationships among the explanatory variables [74].

The data also make it possible to establish links with the literature.

The hypotheses formulated by Achemoglu [75,76] and Redding [77] appear to be fully confirmed by the data. Three main determinants of innovation were observed at the regional level. Within these determinants, the geography of higher education plays an important but not exclusive and decisive role as evidenced by Figure 8. Indeed, it is necessary to support education and training policies with other types of complementary policies, i.e., the innovation support policies, although it is clear from our data that R&D investments also play an important role [78,79].

Therefore, the geography of Higher Education must be anchored to a "harmonious" set of policies that is able to connect different policy sectors to promote entrepreneurship, innovation, and research. Cicione et al. [80] and Marino [81] describe it as "harmonic innovation" using the metaphor of the orchestra, which implies that although composed of different instruments, it can create a harmony of sounds if managed by a good conductor. The instruments are the policies, and the conductor is the policymaker. Therefore, if appropriate policies can be combined with the geography of Higher Education in a holistic perspective, regional performance, in terms of innovation, can improve. From this perspective, the relationship between the geography of higher education and the geography of innovation becomes clearer. Although the former constitutes an important driver, in order to fully explain regional innovation differentials, it is necessary to consider not only the different policies but also their degree of harmony [82].

The variable population with tertiary education was found to be poorly correlated with the other variables. In other words, while significant on its own, it does not develop interrelationships with the other groups of variables that determine innovation at the regional level, leading to the same conclusion that policies whose sole purpose is to increase the number of students with tertiary education have no impact on welfare and may have generated imbalances, lower economic equilibria, and may lead to future discontent [13,83,84].

To examining the complex interaction between regional innovation and geography of HEIs, it is necessary to identify policy linkages that are able to explain the different classification of regions (star, dog, under-performant, over-performant), which is associated with different stages of innovation as evident from Figure 7 and Table 8 different. these linkages are represented by the three aggregate variables representing the latent structure of regional innovation identified through the PLS model with the addition of a fourth dimension of regional development. Thus, the four policy areas are represented by Higher Education, Innovation Policies, Entrepreneurship and R&D, and Regional Development.

Table 8. Standardised coefficients of the regression model.

Source	Value	Standard Error	t-Value	Pr > |t|	Lower Bound (95%)	Upper Bound (95%)
Population with tertiary education	0.059	0.016	3.601	0.000	0.027	0.092
Lifelong learning	0.113	0.024	4.673	<0.0001	0.065	0.160
International scientific co-publications	0.011	0.044	0.259	0.796	−0.075	0.098
Most-cited publications	0.108	0.019	5.700	<0.0001	0.071	0.146
Digital skills	0.161	0.025	6.411	<0.0001	0.112	0.211
R&D expenditures public sector	0.082	0.019	4.215	<0.0001	0.043	0.120
R&D expenditures business sector	0.054	0.025	2.105	0.037	0.003	0.104
Non-R&D innovation expenditures	0.060	0.017	3.507	0.001	0.026	0.094
Innovation expenditures per person employed	0.074	0.021	3.531	0.001	0.032	0.115
IT specialists	0.107	0.022	4.791	<0.0001	0.063	0.152
Product process innovators	−0.013	0.032	−0.409	0.683	−0.075	0.050
Business process innovators	0.161	0.040	4.026	<0.0001	0.082	0.239
Innovative SMEs collaborating with others	0.079	0.022	3.647	0.000	0.036	0.122
Public–private co-publications	0.099	0.047	2.082	0.039	0.005	0.192
PCT patent applications	0.148	0.031	4.825	<0.0001	0.087	0.208
Trademark applications	0.034	0.019	1.759	0.081	−0.004	0.072
Design applications	0.062	0.017	3.666	0.000	0.028	0.095
Employment knowledge-intensive activities	0.085	0.020	4.226	<0.0001	0.045	0.125
Employment in innovative SMEs	0.004	0.036	0.109	0.914	−0.067	0.074
Sales of new-to-market and new-to-firm innovations	−0.005	0.017	−0.283	0.777	−0.039	0.029
N. of Universities	0.042	0.017	2.434	0.016	0.008	0.076
Total Academic Personnel (FTE)	0.016	0.016	0.970	0.334	−0.017	0.049

The first level of complexity is offered by the presence of two "levels" of government [85]. The first is an implicit national government, which, in most jurisdictions, is responsible for higher education, research, innovation, etc., and the second is a subnational government, which is in charge of regional development policy. In the policy framework that characterises the "geography of higher education", the subnational authority plays a key role. However, this policy subject can be difficult to link to HEIs that are not responsive to their surrounding communities [86,87].

Hence, innovation can be considered a complex issue to manage in terms of policies [88,89]. Direct incentives to companies for innovation become less decisive, which, until recently, could be considered fundamental in playing a key role in the overall process. Innovation takes on systemic connotations where complementary policies, higher education, and R&D assume relevance [90–92]. The data show that regions that strongly incentivise innovation policies at the enterprise level, while neglecting systemic aspects, depict lower levels of innovation, thereby relying on sectoral policies or limiting itself to provide direct incentives for innovation, which gives rise to a sub-optimal result [93,94]. In particular, the results of the paper, answering the research questions, highlight the importance of the geography of higher education as a guideline for reorienting systemic innovation policies is emphasised.

6. Conclusions

This paper is one of the first attempts to discuss the role of HEIs within regional innovation systems. The empirical analysis, which considered many variables contributing to regional innovation, confirms that HEIs are a necessary, but non-sufficient component of the regional innovation system. This finding is in line with existing literature on the

role of HEIs in regional innovation systems. Positive narratives inspired by the stories of Stanford, MIT, and a few other global champions tend to overemphasise the role of higher education institutions in their own innovation and entrepreneurial ecosystems. While policymakers and a few stakeholders consider HEIs as a source of innovation—"fountains of knowledge"—there are several factors impinging upon the capacity of HEIs to actively contribute to innovation and entrepreneurship, including the lack of skills, capacities, and incentives.

To connect HEIs to regional innovation systems, there is a need for a holistic approach that operates from the perspective of higher education policy—removing barriers to collaboration, innovation and entrepreneurship—and creates synergies with other policy areas, such as innovation, and regional development. Policymakers aiming at promoting regional innovation systems should consider these findings and operate to remove trade-offs simultaneously in order to promote a "harmonic" dynamic in regions [95]. Such an approach could help transform "dogs" if not into "stars" to venture into regions that achieve a given level of productivity that allows them to contribute to international supply chains and innovation activities. A promising future research development may be to highlight the role of policy complementarity in the regional innovation process.

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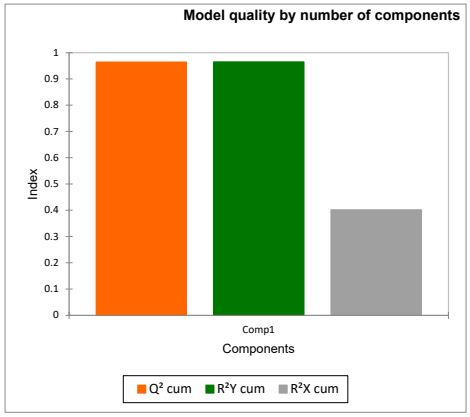
Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. PLSR Model.



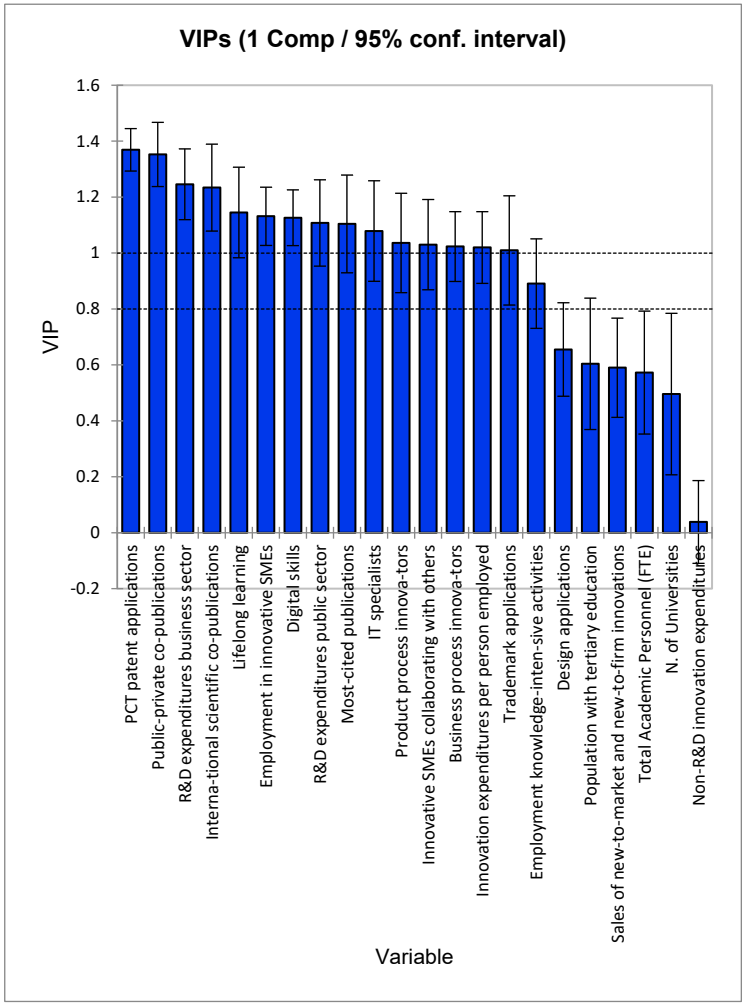
Model Quality:

Table A1. *Cont.*

Statistic	Comp1	
Q^2 cum		0.964
R^2Y cum		0.965
R^2X cum		0.401
Correlation matrix of the variables with the t and u~ components:	t1	u~1
Population with tertiary education	0.374	0.375
Lifelong learning	0.659	0.711
International scientific co-publications	0.805	0.767
Most-cited publications	0.678	0.686
Digital skills	0.638	0.700
R&D expenditures public sector	0.702	0.688
R&D expenditures business sector	0.771	0.774
Non-R&D innovation expenditures	0.033	0.024
Innovation expenditures per person employed	0.651	0.634
IT specialists	0.667	0.670
Product process innovators	0.699	0.644
Business process innovators	0.685	0.636
Innovative SMEs collaborating with others	0.676	0.640
Public–private co-publications	0.870	0.841
PCT patent applications	0.832	0.851
Trademark applications	0.654	0.627
Design applications	0.413	0.407
Employment knowledge-intensive activities	0.560	0.554
Employment in innovative SMEs	0.749	0.703
Sales of new-to-market and new-to-firm innovations	0.431	0.367
N. of Universities	0.339	0.308
Total Academic Personnel (FTE)	0.380	0.356
EIS	0.982	1.003

Variable Importance in the Projection (VIP):

Variable	VIP	Standard Deviation	Lower Bound (95%)	Upper Bound (95%)
PCT patent applications	1.369	0.034	1.293	1.445
Public–private co-publications	1.353	0.051	1.238	1.467
R&D expenditures business sector	1.246	0.056	1.119	1.372
International scientific co-publications	1.234	0.069	1.079	1.389
Lifelong learning	1.145	0.072	0.983	1.307
Employment in innovative SMEs	1.131	0.046	1.027	1.236
Digital skills	1.126	0.044	1.026	1.226
R&D expenditures public sector	1.108	0.068	0.954	1.262
Most-cited publications	1.104	0.077	0.930	1.279
IT specialists	1.079	0.079	0.899	1.258
Product process innovators	1.036	0.078	0.859	1.214
Innovative SMEs collaborating with others	1.030	0.071	0.869	1.191
Business process innovators	1.023	0.055	0.898	1.148
Innovation expenditures per person employed	1.020	0.057	0.892	1.148
Trademark applications	1.010	0.086	0.814	1.205
Employment knowledge-intensive activities	0.891	0.071	0.731	1.051
Design applications	0.655	0.074	0.488	0.822
Population with tertiary education	0.604	0.104	0.369	0.839
Sales of new-to-market and new-to-firm innovations	0.590	0.078	0.413	0.767
Total Academic Personnel (FTE)	0.573	0.097	0.353	0.792
N. of Universities	0.496	0.128	0.207	0.784
Non-R&D innovation expenditures	0.038	0.065	−0.109	0.186

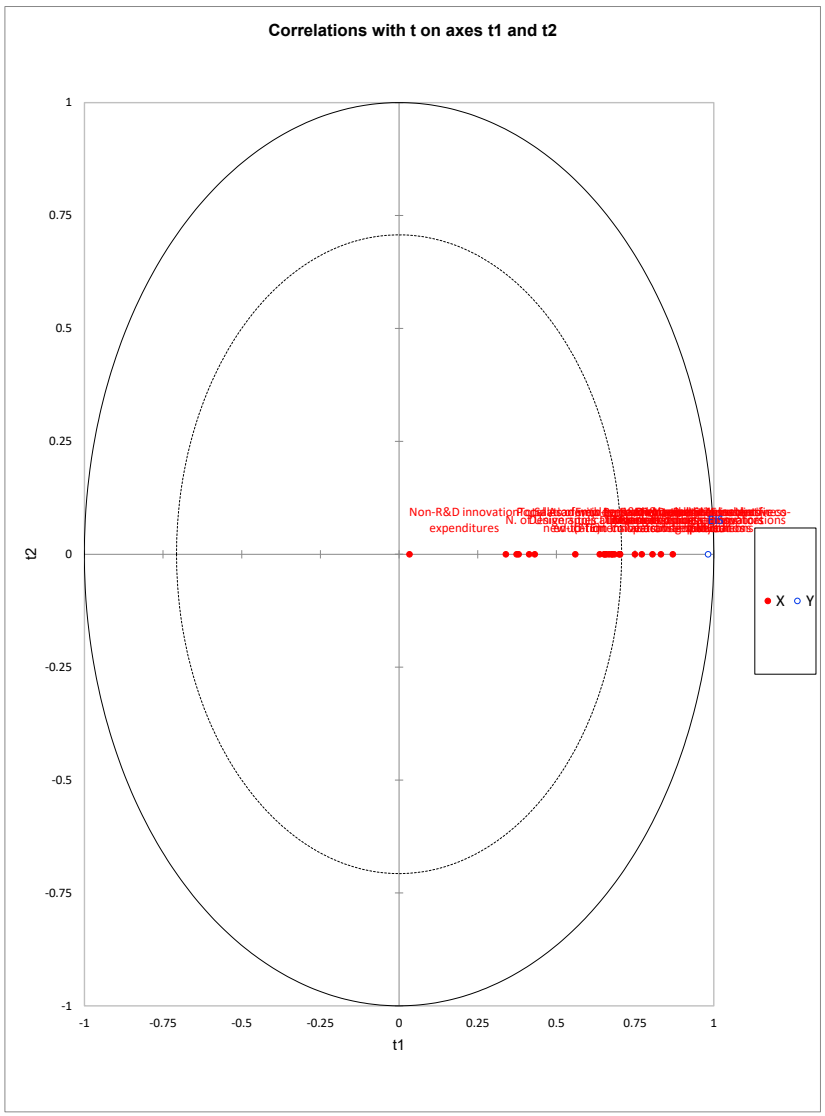


Coefficients (Variable EIS):

Variable	Coefficient	Std. Deviation	Lower Bound (95%)	Upper Bound (95%)
Intercept	6.225	1.064	3.818	8.633
Population with tertiary education	4.879	0.848	2.959	6.798
Lifelong learning	8.247	0.555	6.991	9.503
International scientific co-publications	10.583	0.670	9.068	12.098
Most-cited publications	11.103	0.810	9.271	12.936
Digital skills	9.841	0.407	8.920	10.762
R&D expenditures public sector	9.316	0.617	7.920	10.712
R&D expenditures business sector	10.222	0.418	9.277	11.168
Non-R&D innovation expenditures	0.488	1.093	−1.985	2.962
Innovation expenditures per person employed	10.703	0.595	9.357	12.049
IT specialists	7.868	0.608	6.492	9.244
Product process innovators	8.584	0.614	7.194	9.974
Business process innovators	6.827	0.349	6.038	7.615
Innovative SMEs collaborating with others	8.232	0.551	6.986	9.477
Public–private co-publications	11.477	0.511	10.322	12.632
PCT patent applications	11.205	0.237	10.669	11.741
Trademark applications	9.523	0.810	7.691	11.355
Design applications	5.702	0.651	4.228	7.175
Employment knowledge-intensive activities	7.060	0.554	5.808	8.312
Employment in innovative SMEs	8.043	0.287	7.395	8.692
Sales of new-to-market and new-to-firm innovations	6.167	0.822	4.308	8.026
N. of Universities	7.025	1.773	3.014	11.036
Total Academic Personnel (FTE)	8.990	1.481	5.641	12.340

VIDs (Variable EIS):

Variable	VID	Std. Deviation	Lower Bound (95%)	Upper Bound (95%)
Population with tertiary education	0.374	0.011	0.348	0.399
Lifelong learning	0.659	0.007	0.643	0.675
International scientific co-publications	0.805	0.005	0.793	0.818
Most-cited publications	0.678	0.007	0.662	0.694
Digital skills	0.638	0.007	0.623	0.653
R&D expenditures public sector	0.702	0.004	0.694	0.711
R&D expenditures business sector	0.771	0.005	0.760	0.783
Non-R&D innovation expenditures	0.033	0.008	0.014	0.052
Innovation expenditures per person employed	0.651	0.005	0.641	0.662
IT specialists	0.667	0.008	0.650	0.685
Product process innovators	0.699	0.009	0.679	0.720
Business process innovators	0.685	0.010	0.662	0.707
Innovative SMEs collaborating with others	0.676	0.007	0.660	0.692
Public–private co-publications	0.870	0.004	0.861	0.879
PCT patent applications	0.832	0.003	0.825	0.839
Trademark applications	0.654	0.006	0.640	0.668
Design applications	0.413	0.008	0.396	0.431
Employment knowledge-intensive activities	0.560	0.007	0.543	0.577
Employment in innovative SMEs	0.749	0.008	0.731	0.768
Sales of new-to-market and new-to-firm innovations	0.431	0.008	0.412	0.450
N. of Universities	0.339	0.012	0.312	0.367
Total Academic Personnel (FTE)	0.380	0.010	0.357	0.403



w Vectors:	
Variable	**w1**
Population with tertiary education	0.129
Lifelong learning	0.244
International scientific co-publications	0.263
Most-cited publications	0.235
Digital skills	0.240
R&D expenditures public sector	0.236
R&D expenditures business sector	0.266
Non-R&D innovation expenditures	0.008
Innovation expenditures per person employed	0.217
IT specialists	0.230
Product process innovators	0.221
Business process innovators	0.218
Innovative SMEs collaborating with others	0.220
Public–private co-publications	0.288
PCT patent applications	0.292
Trademark applications	0.215
Design applications	0.140
Employment knowledge-intensive activities	0.190
Employment in innovative SMEs	0.241
Sales of new-to-market and new-to-firm innovations	0.126
N. of Universities	0.106
Total Academic Personnel (FTE)	0.122

w* Vectors:	
Variable	**w*1**
Population with tertiary education	0.129
Lifelong learning	0.244
International scientific co-publications	0.263
Most-cited publications	0.235
Digital skills	0.240
R&D expenditures public sector	0.236
R&D expenditures business sector	0.266
Non-R&D innovation expenditures	0.008
Innovation expenditures per person employed	0.217
IT specialists	0.230
Product process innovators	0.221
Business process innovators	0.218
Innovative SMEs collaborating with others	0.220
Public–private co-publications	0.288
PCT patent applications	0.292
Trademark applications	0.215
Design applications	0.140
Employment knowledge-intensive activities	0.190
Employment in innovative SMEs	0.241
Sales of new-to-market and new-to-firm innovations	0.126
N. of Universities	0.106
Total Academic Personnel (FTE)	0.122

c Vectors:	
Variable	**c1**
EIS	0.331

Scores on t:	
Observation	**t1**
Région de Bruxelles-Capitale	4.546
Vlaams Gewest	4.240
Région wallonne	2.462
Praha	2.637
Střední Čechy	−0.103
Jihozápad	−1.522
Severozápad	−4.617

Scores on t:	
Observation	**t1**
Severovýchod	−1.245
Jihovýchod	−0.011
Střední Morava	−1.590
Moravskoslezsko	−1.454
Hovedstaden	6.826
Sjælland	0.953
Syddanmark	2.278
Midtjylland	4.570
Nordjylland	3.254
Northern and Western	0.187
Southern	0.844
Eastern and Midland	2.304
Attiki	1.336
Voreio Aigaio	−1.714
Notio Aigaio	−4.027
Kriti	0.450
Anatoliki Makedonia, Thraki	−2.494
Kentriki Makedonia	0.256
Dytiki Makedonia	−3.569
Ipeiros	−0.919
Thessalia	−0.637
Ionia Nisia	−2.892
Dytiki Ellada	−0.709
Sterea Ellada	−2.349
Peloponnisos	−2.712
Galicia	−1.724
Principado de Asturias	−2.145
Cantabria	−2.038
País Vasco	1.100
Comunidad Foral de Navarra	0.228
La Rioja	−1.589
Aragón	−1.506
Comunidad de Madrid	0.990
Castilla y León	−2.062
Castilla-la Mancha	−3.290
Extremadura	−3.764
Cataluña	0.843
Comunitat Valenciana	−0.353
Illes Balears	−2.915
Andalucía	−2.465
Región de Murcia	−1.917
Canarias	−4.374
Île de France	4.639
Centre–Val de Loire	−0.828
Bourgogne–Franche-Comté	−0.741
Normandie	−1.798
Hauts-de-France	−0.959
Grand Est	−0.166
Pays de la Loire	0.206
Bretagne	1.273
Nouvelle-Aquitaine	−0.286
Occitanie	2.381
Auvergne–Rhône-Alpes	2.495
Provence-Alpes-Côte d'Azur	0.996
Corse	−5.089
Régions ultrapériphériques françaises	−3.119
Piemonte	1.558
Valle d'Aosta/Vallée d'Aoste	−3.312
Liguria	−0.785
Lombardia	2.384
Provincia Autonoma Bolzano/Bozen	0.985
Provincia Autonoma Trento	2.445
Veneto	2.176
Friuli-Venezia Giulia	2.138
Emilia-Romagna	2.704
Toscana	1.861
Umbria	1.348
Marche	0.123
Lazio	1.684
Abruzzo	−0.414
Molise	−0.418

Scores on t:	
Observation	**t1**
Campania	−0.386
Puglia	−1.345
Basilicata	−1.232
Calabria	−2.229
Sicilia	−1.932
Sardegna	−1.567
Sostinės regionas	1.584
Vidurio ir vakarų Lietuvos regionas	−2.378
Budapest	1.309
Pest	−2.602
Közép-Dunántúl	−3.441
Nyugat-Dunántúl	−3.942
Dél-Dunántúl	−4.264
Észak-Magyarország	−4.353
Észak-Alföld	−4.040
Dél-Alföld	−3.440
Groningen	2.499
Friesland	0.308
Drenthe	−0.110
Overijssel	2.100
Gelderland	3.231
Flevoland	1.584
Utrecht	3.902
Noord-Holland	3.928
Zuid-Holland	3.490
Zeeland	0.068
Noord-Brabant	3.770
Limburg	3.296
Ostösterreich	4.615
Südösterreich	3.779
Westösterreich	3.405
• Dolnośląskie	−1.587
• Kujawsko-Pomorskie	−3.898
• Lubelskie	−3.765
• Lubuskie	−4.692
• Łódzkie	−4.778
• Małopolskie	−2.590
• Opolskie	−4.363
• Podkarpackie	−4.330
• Podlaskie	−5.193
• Pomorskie	−2.775
• Śląskie	−3.678
• Świętokrzyskie	−5.356
• Warmińsko-Mazurskie	−3.932
• Wielkopolskie	−3.671
• Zachodniopomorskie	−4.483
• Mazowiecki regionalny	0.482
• Warszawski stołeczny	−5.821
Norte	−0.223
Algarve	−3.148
Centro	−0.585
Lisboa	1.206
Alentejo	−2.278
Região Autónoma dos Açores	−4.030
Região Autónoma da Madeira	−3.252
Vzhodna Slovenija	−0.088
Zahodna Slovenija	2.215
Bratislavský kraj	0.266
Západné Slovensko	−3.534
Stredné Slovensko	−3.309
Vachon Slovensko	−3.556
Helsinki-Uusimaa	7.554
Etelä-Suomi	3.453
Länsi-Suomi	4.861
Pohjois-ja Itä-Suomi	3.609
Åland	0.205
Stockholm	7.410
Östra Mellansverige	5.078
Småland med öarna	1.894
Sydsverige	5.989

Scores on t:	
Observation	**t1**
Västsverige	5.582
Norra Mellansverige	0.947
Mellersta Norrland	0.828
Övre Norrland	3.203
Baden-Württemberg	5.195
Bavaria	3.558
Berlin	5.477
Brandenburg	0.345
Bremen	2.324
Hamburg	4.387
Hesse	2.751
Mecklenburg-Vorpommern	−0.099
Lower Saxony	1.874
North Rhine-Westphalia	3.467
Rhineland-Palatinate	1.821
Saarland	1.408
Saxony	2.189
Sachsen-Anhalt	−0.156
Schleswig-Holstein	1.602
Thüringen	1.305

Standardized Scores on t:	
Observation	**t1**
Région de Bruxelles-Capitale	0.118
Vlaams Gewest	0.110
Région wallonne	0.064
Praha	0.069
Střední Čechy	−0.003
Jihozápad	−0.040
Severozápad	−0.120
Severovýchod	−0.032
Jihovýchod	0.000
Střední Morava	−0.041
Moravskoslezsko	−0.038
Hovedstaden	0.177
Sjælland	0.025
Syddanmark	0.059
Midtjylland	0.119
Nordjylland	0.085
Northern and Western	0.005
Southern	0.022
Eastern and Midland	0.060
Attiki	0.035
Voreio Aigaio	−0.045
Notio Aigaio	−0.105
Kriti	0.012
Anatoliki Makedonia, Thraki	−0.065
Kentriki Makedonia	0.007
Dytiki Makedonia	−0.093
Ipeiros	−0.024
Thessalia	−0.017
Ionia Nisia	−0.075
Dytiki Ellada	−0.018
Sterea Ellada	−0.061
Peloponnisos	−0.071
Galicia	−0.045
Principado de Asturias	−0.056
Cantabria	−0.053
País Vasco	0.029
Comunidad Foral de Navarra	0.006
La Rioja	−0.041
Aragón	−0.039
Comunidad de Madrid	0.026
Castilla y León	−0.054
Castilla-la Mancha	−0.086

Scores on t:	
Observation	**t1**
Extremadura	−0.098
Cataluña	0.022
Comunitat Valenciana	−0.009
Illes Balears	−0.076
Andalucía	−0.064
Región de Murcia	−0.050
Canarias	−0.114
Île de France	0.121
Centre–Val de Loire	−0.022
Bourgogne–Franche-Comté	−0.019
Normandie	−0.047
Hauts-de-France	−0.025
Grand Est	−0.004
Pays de la Loire	0.005
Bretagne	0.033
Nouvelle-Aquitaine	−0.007
Occitanie	0.062
Auvergne–Rhône-Alpes	0.065
Provence-Alpes-Côte d'Azur	0.026
Corse	−0.132
Régions ultrapériphériques françaises	−0.081
Piemonte	0.041
Valle d'Aosta/Vallée d'Aoste	−0.086
Liguria	−0.020
Lombardia	0.062
Provincia Autonoma Bolzano/Bozen	0.026
Provincia Autonoma Trento	0.064
Veneto	0.057
Friuli-Venezia Giulia	0.056
Emilia-Romagna	0.070
Toscana	0.048
Umbria	0.035
Marche	0.003
Lazio	0.044
Abruzzo	−0.011
Molise	−0.011
Campania	−0.010
Puglia	−0.035
Basilicata	−0.032
Calabria	−0.058
Sicilia	−0.050
Sardegna	−0.041
Sostinės regionas	0.041
Vidurio ir vakarų Lietuvos regionas	−0.062
Budapest	0.034
Pest	−0.068
Közép-Dunántúl	−0.089
Nyugat-Dunántúl	−0.102
Dél-Dunántúl	−0.111
Észak-Magyarország	−0.113
Észak-Alföld	−0.105
Dél-Alföld	−0.089
Groningen	0.065
Friesland	0.008
Drenthe	−0.003
Overijssel	0.055
Gelderland	0.084
Flevoland	0.041
Utrecht	0.101
Noord-Holland	0.102
Zuid-Holland	0.091
Zeeland	0.002
Noord-Brabant	0.098
Limburg	0.086
Ostösterreich	0.120
Südösterreich	0.098
Westösterreich	0.089
Malopolskie	−0.041
Slaskie	−0.101
Wielkopolskie	−0.098
Zachodniopomorskie	−0.122

Scores on t:	
Observation	**t1**
Lubuskie	−0.124
Dolnoslaskie	−0.067
Opolskie	−0.113
Kujawsko-Pomorskie	−0.113
Warminsko-Mazurskie	−0.135
Pomorskie	−0.072
Lódzkie	−0.096
Swietokrzyskie	−0.139
Lubelskie	−0.102
Podkarpackie	−0.095
Podlaskie	−0.117
Warszawski stoleczny	0.013
Mazowiecki regionalny	−0.151
Norte	−0.006
Algarve	−0.082
Centro	−0.015
Lisboa	0.031
Alentejo	−0.059
Região Autónoma dos Açores	−0.105
Região Autónoma da Madeira	−0.085
Vzhodna Slovenija	−0.002
Zahodna Slovenija	0.058
Bratislavský kraj	0.007
Západné Slovensko	−0.092
Stredné Slovensko	−0.086
Vachon Slovensko	−0.092
Helsinki-Uusimaa	0.196
Etelä-Suomi	0.090
Länsi-Suomi	0.126
Pohjois-ja Itä-Suomi	0.094
Åland	0.005
Stockholm	0.193
Östra Mellansverige	0.132
Småland med öarna	0.049
Sydsverige	0.156
Västsverige	0.145
Norra Mellansverige	0.025
Mellersta Norrland	0.022
Övre Norrland	0.083
Baden-Württemberg	0.135
Bavaria	0.092
Berlin	0.142
Brandenburg	0.009
Bremen	0.060
Hamburg	0.114
Hesse	0.072
Mecklenburg-Vorpommern	−0.003
Lower Saxony	0.049
North Rhine-Westphalia	0.090
Rhineland-Palatinate	0.047
Saarland	0.037
Saxony	0.057
Sachsen-Anhalt	−0.004
Schleswig-Holstein	0.042
Thüringen	0.034

Scores on u:	
Observation	**u1**
Région de Bruxelles-Capitale	5.078
Vlaams Gewest	4.564
Région wallonne	2.744
Praha	2.027
Strední Cechy	−0.046
Jihozápad	−1.677
Severozápad	−4.567
Severovýchod	−1.078
Jihovýchod	−0.061
Strední Morava	−1.716

Scores on u:	
Observation	**u1**
Moravskoslezsko	−1.588
Hovedstaden	6.611
Sjælland	1.092
Syddanmark	2.191
Midtjylland	4.759
Nordjylland	3.068
Northern and Western	0.833
Southern	1.506
Eastern and Midland	2.838
Attiki	−0.256
Voreio Aigaio	−2.849
Notio Aigaio	−4.589
Kriti	−0.784
Anatoliki Makedonia, Thraki	−3.625
Kentriki Makedonia	−1.253
Dytiki Makedonia	−4.387
Ipeiros	−2.006
Thessalia	−1.633
Ionia Nisia	−3.203
Dytiki Ellada	−1.921
Sterea Ellada	−2.937
Peloponnisos	−3.332
Galicia	−1.131
Principado de Asturias	−1.712
Cantabria	−1.728
País Vasco	1.598
Comunidad Foral de Navarra	0.984
La Rioja	−0.941
Aragón	−0.916
Comunidad de Madrid	1.305
Castilla y León	−1.359
Castilla-la Mancha	−2.742
Extremadura	−3.097
Cataluña	1.077
Comunitat Valenciana	0.240
Illes Balears	−2.403
Andalucía	−2.391
Región de Murcia	−1.422
Canarias	−4.462
Île de France	4.506
Centre–Val de Loire	−0.094
Bourgogne–Franche-Comté	0.043
Normandie	−1.324
Hauts-de-France	−0.650
Grand Est	0.580
Pays de la Loire	1.103
Bretagne	2.118
Nouvelle-Aquitaine	0.438
Occitanie	3.092
Auvergne–Rhône-Alpes	2.965
Provence-Alpes-Côte d'Azur	1.732
Corse	−4.571
Régions ultrapériphériques françaises	−2.338
Piemonte	0.953
Valle d'Aosta/Vallée d'Aoste	−2.408
Liguria	−0.102
Lombardia	1.449
Provincia Autonoma Bolzano/Bozen	0.626
Provincia Autonoma Trento	1.979
Veneto	1.500
Friuli-Venezia Giulia	1.928
Emilia-Romagna	2.238
Toscana	1.341
Umbria	1.061
Marche	0.153
Lazio	1.235
Abruzzo	−0.493
Molise	−0.695
Campania	−0.649
Puglia	−1.662
Basilicata	−1.045
Calabria	−2.319

Scores on u:	
Observation	**u1**
Sicilia	−2.090
Sardegna	−2.070
Sostinės regionas	1.491
Vidurio ir vakarų Lietuvos regionas	−2.358
Budapest	0.926
Pest	−2.560
Közép-Dunántúl	−3.473
Nyugat-Dunántúl	−3.803
Dél-Dunántúl	−4.451
Észak-Magyarország	−4.432
Észak-Alföld	−4.229
Dél-Alföld	−3.521
Groningen	2.933
Friesland	0.905
Drenthe	0.591
Overijssel	2.554
Gelderland	3.646
Flevoland	2.272
Utrecht	4.541
Noord-Holland	4.544
Zuid-Holland	3.789
Zeeland	0.615
Noord-Brabant	4.325
Limburg	3.639
Ostösterreich	3.522
Südösterreich	3.057
Westösterreich	2.866
Malopolskie	−1.996
Slaskie	−4.270
Wielkopolskie	−4.077
Zachodniopomorskie	−4.630
Lubuskie	−4.602
Dolnoslaskie	−2.727
Opolskie	−4.505
Kujawsko-Pomorskie	−4.404
Warminsko-Mazurskie	−5.156
Pomorskie	−2.826
Lódzkie	−4.016
Swietokrzyskie	−5.353
Lubelskie	−4.003
Podkarpackie	−3.554
Podlaskie	−4.403
Warszawski stoleczny	−0.118
Mazowiecki regionalny	−5.843
Norte	−0.979
Algarve	−3.487
Centro	−1.142
Lisboa	0.056
Alentejo	−2.487
Região Autónoma dos Açores	−4.770
Região Autónoma da Madeira	−3.933
Vzhodna Slovenija	−1.039
Zahodna Slovenija	0.987
Bratislavský kraj	−0.190
Západné Slovensko	−3.718
Stredné Slovensko	−3.500
Vachon Slovensko	−3.821
Helsinki-Uusimaa	6.910
Etelä-Suomi	3.074
Länsi-Suomi	4.592
Pohjois- ja Itä-Suomi	3.249
Åland	2.219
Stockholm	7.222
Östra Mellansverige	4.819
Småland med öarna	2.351
Sydsverige	5.817
Västsverige	5.370
Norra Mellansverige	1.276
Mellersta Norrland	1.318
Övre Norrland	3.319
Baden-Württemberg	4.908

Scores on u:	
Observation	**u1**
Bavaria	3.286
Berlin	6.039
Brandenburg	0.744
Bremen	2.607
Hamburg	4.879
Hesse	3.065
Mecklenburg-Vorpommern	0.493
Lower Saxony	2.005
North Rhine-Westphalia	2.753
Rhineland-Palatinate	2.391
Saarland	1.971
Saxony	2.716
Sachsen-Anhalt	0.451
Schleswig-Holstein	2.059
Thüringen	1.983

Scores on u~:	
Observation	**u~1**
Région de Bruxelles-Capitale	5.078
Vlaams Gewest	4.564
Région wallonne	2.744
Praha	2.027
Střední Čechy	−0.046
Jihozápad	−1.677
Severozápad	−4.567
Severovýchod	−1.078
Jihovýchod	−0.061
Střední Morava	−1.716
Moravskoslezsko	−1.588
Hovedstaden	6.611
Sjælland	1.092
Syddanmark	2.191
Midtjylland	4.759
Nordjylland	3.068
Northern and Western	0.833
Southern	1.506
Eastern and Midland	2.838
Attiki	−0.256
Voreio Aigaio	−2.849
Notio Aigaio	−4.589
Kriti	−0.784
Anatoliki Makedonia. Thraki	−3.625
Kentriki Makedonia	−1.253
Dytiki Makedonia	−4.387
Ipeiros	−2.006
Thessalia	−1.633
Ionia Nisia	−3.203
Dytiki Ellada	−1.921
Sterea Ellada	−2.937
Peloponnisos	−3.332
Galicia	−1.131
Principado de Asturias	−1.712
Cantabria	−1.728
País Vasco	1.598
Comunidad Foral de Navarra	0.984
La Rioja	−0.941
Aragón	−0.916
Comunidad de Madrid	1.305
Castilla y León	−1.359
Castilla-la Mancha	−2.742
Extremadura	−3.097
Cataluña	1.077
Comunitat Valenciana	0.240
Illes Balears	−2.403
Andalucía	−2.391
Región de Murcia	−1.422

Scores on u~:	
Observation	**u~1**
Canarias	−4.462
Île de France	4.506
Centre-Val de Loire	−0.094
Bourgogne-Franche-Comté	0.043
Normandie	−1.324
Hauts-de-France	−0.650
Grand Est	0.580
Pays de la Loire	1.103
Bretagne	2.118
Nouvelle-Aquitaine	0.438
Occitanie	3.092
Auvergne-Rhône-Alpes	2.965
Provence-Alpes-Côte d'Azur	1.732
Corse	−4.571
Régions ultrapériphériques françaises	−2.338
Piemonte	0.953
Valle d'Aosta/Vallée d'Aoste	−2.408
Liguria	−0.102
Lombardia	1.449
Provincia Autonoma Bolzano/Bozen	0.626
Provincia Autonoma Trento	1.979
Veneto	1.500
Friuli-Venezia Giulia	1.928
Emilia-Romagna	2.238
Toscana	1.341
Umbria	1.061
Marche	0.153
Lazio	1.235
Abruzzo	−0.493
Molise	−0.695
Campania	−0.649
Puglia	−1.662
Basilicata	−1.045
Calabria	−2.319
Sicilia	−2.090
Sardegna	−2.070
Sostinės regionas	1.491
Vidurio ir vakarų Lietuvos regionas	−2.358
Budapest	0.926
Pest	−2.560
Közép-Dunántúl	−3.473
Nyugat-Dunántúl	−3.803
Dél-Dunántúl	−4.451
Észak-Magyarország	−4.432
Észak-Alföld	−4.229
Dél-Alföld	−3.521
Groningen	2.933
Friesland	0.905
Drenthe	0.591
Overijssel	2.554
Gelderland	3.646
Flevoland	2.272
Utrecht	4.541
Noord-Holland	4.544
Zuid-Holland	3.789
Zeeland	0.615
Noord-Brabant	4.325
Limburg	3.639
Ostösterreich	3.522
Südösterreich	3.057
Westösterreich	2.866
Malopolskie	−1.996
Slaskie	−4.270
Wielkopolskie	−4.077
Zachodniopomorskie	−4.630
Lubuskie	−4.602
Dolnoslaskie	−2.727
Opolskie	−4.505
Kujawsko-Pomorskie	−4.404
Warminsko-Mazurskie	−5.156
Pomorskie	−2.826

Scores on u~:	
Observation	**u~1**
Lódzkie	−4.016
Swietokrzyskie	−5.353
Lubelskie	−4.003
Podkarpackie	−3.554
Podlaskie	−4.403
Warszawski stoleczny	−0.118
Mazowiecki regionalny	−5.843
Norte	−0.979
Algarve	−3.487
Centro	−1.142
Lisboa	0.056
Alentejo	−2.487
Região Autónoma dos Açores	−4.770
Região Autónoma da Madeira	−3.933
Vzhodna Slovenija	−1.039
Zahodna Slovenija	0.987
Bratislavský kraj	−0.190
Západné Slovensko	−3.718
Stredné Slovensko	−3.500
Vachon Slovensko	−3.821
Helsinki-Uusimaa	6.910
Etelä-Suomi	3.074
Länsi-Suomi	4.592
Pohjois-ja Itä-Suomi	3.249
Åland	2.219
Stockholm	7.222
Östra Mellansverige	4.819
Småland med öarna	2.351
Sydsverige	5.817
Västsverige	5.370
Norra Mellansverige	1.276
Mellersta Norrland	1.318
Övre Norrland	3.319
Baden-Württemberg	4.908
Bavaria	3.286
Berlin	6.039
Brandenburg	0.744
Bremen	2.607
Hamburg	4.879
Hesse	3.065
Mecklenburg-Vorpommern	0.493
Lower Saxony	2.005
North Rhine-Westphalia	2.753
Rhineland-Palatinate	2.391
Saarland	1.971
Saxony	2.716
Sachsen-Anhalt	0.451
Schleswig-Holstein	2.059
Thüringen	1.983

Q^2 Quality Index:	
Component	**Comp1**
EIS	0.964
Total	0.964

Cumulative Q^2 Quality Index:	
Component	**Comp1**
EIS	0.964
Total	0.964

R^2 and Redundancy of (X, t):	
Variable	**t1**
Population with tertiary education	0.140
Lifelong learning	0.434
International scientific co-publications	0.649
Most-cited publications	0.459
Digital skills	0.407
R&D expenditures public sector	0.493
R&D expenditures business sector	0.595
Non-R&D innovation expenditures	0.001
Innovation expenditures per person employed	0.424
IT specialists	0.445
Product process innovators	0.489
Business process innovators	0.469
Innovative SMEs collaborating with others	0.457
Public–private co-publications	0.757
PCT patent applications	0.692
Trademark applications	0.428
Design applications	0.171
Employment knowledge-intensive activities	0.314
Employment in innovative SMEs	0.562
Sales of new-to-market and new-to-firm innovations	0.186
N. of Universities	0.115
Total Academic Personnel (FTE)	0.144
Redundancy	0.401

Cumulative Redundancy of (X, t):	
Variable	**t1**
Population with tertiary education	0.140
Lifelong learning	0.434
International scientific co-publications	0.649
Most-cited publications	0.459
Digital skills	0.407
R&D expenditures public sector	0.493
R&D expenditures business sector	0.595
Non-R&D innovation expenditures	0.001
Innovation expenditures per person employed	0.424
IT specialists	0.445
Product process innovators	0.489
Business process innovators	0.469
Innovative SMEs collaborating with others	0.457
Public–private co-publications	0.757
PCT patent applications	0.692
Trademark applications	0.428
Design applications	0.171
Employment knowledge-intensive activities	0.314
Employment in innovative SMEs	0.562
Sales of new-to-market and new-to-firm innovations	0.186
N. of Universities	0.115
Total Academic Personnel (FTE)	0.144
Redundancy	0.401

R^2 and Redundancy of (Y, t):	
Variable	**t1**
EIS	0.965
Redundancy	0.965

Cumulative Redundancy of (Y, t):	
Variable	**Comp1**
EIS	0.965
Redundancy	0.965

Model Parameters:	
Variable	**EIS**
Intercept	6.225
Population with tertiary education	4.879
Lifelong learning	8.247
International scientific co-publications	10.583
Most-cited publications	11.103
Digital skills	9.841
R&D expenditures public sector	9.316
R&D expenditures business sector	10.222
Non-R&D innovation expenditures	0.488
Innovation expenditures per person employed	10.703
IT specialists	7.868
Product process innovators	8.584
Business process innovators	6.827
Innovative SMEs collaborating with others	8.232
Public–private co-publications	11.477
PCT patent applications	11.205
Trademark applications	9.523
Design applications	5.702
Employment knowledge-intensive activities	7.060
Employment in innovative SMEs	8.043
Sales of new-to-market and new-to-firm innovations	6.167
N. of Universities	7.025
Total Academic Personnel (FTE)	8.990

Equation of the Model
EIS = 6.22548520139866 + 4.87858233541995 × Population with tertiary education + 8.24716357233039 × Lifelong learning + 10.5828875451076 × International scientific co-publications + 11.1033774883118 × Most-cited publications + 9.84062696836357 × Digital skills + 9.31573394427755 × R&D expenditures public sector + 10.2223331153399 × R&D expenditures business sector + 0.488384426970825 × Non-R&D innovation expenditures + 10.7028250209873 × Innovation expenditures per person employed + 7.86774201196726 × IT specialists + 8.58447407405854 × Product process innovators + 6.82654191310526 × Business process innovators + 8.23173348858942 × Innovative SMEs collaborating with others + 11.4765962309642 × Public-private co-publications + 11.2050426392537 × PCT patent applications + 9.52298077410616 × Trademark applications + 5.70172145691646 × Design applications + 7.06005704544679 × Employment knowledge-intensive activities + 8.04331847400266 × Employment in innovative SMEs + 6.16689582410951 × Sales of new-to-market and new-to-firm innovations + 7.02470447231464 × N. of Universities + 8.99022348565018 × Total Academic Personnel (FTE)

Results for Variable EIS: **Goodness of Fit Statistics (Variable EIS):**	
Observations	168.000
Sum of weights	168.000
DF	166.000
R^2	0.965
Std. deviation	5.178
MSE	26.496
RMSE	5.147

Table A2. PCR model.

Eigenvectors:																						
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22
Population with tertiary education	0.122	−0.291	−0.045	0.469	−0.125	0.023	−0.309	0.314	−0.279	−0.069	0.129	−0.305	−0.062	0.434	−0.042	−0.185	0.193	0.002	0.069	−0.004	0.068	0.035
Lifelong learning	0.215	−0.141	−0.369	−0.183	−0.173	0.139	0.007	0.131	0.058	−0.357	0.006	0.281	−0.296	0.156	0.027	0.063	−0.210	0.400	−0.381	−0.043	0.039	0.139
International scientific co-publications	0.271	−0.063	−0.066	0.331	0.130	−0.273	0.149	0.008	−0.094	0.134	0.163	0.214	−0.238	−0.077	−0.023	0.275	−0.036	−0.058	−0.142	0.003	−0.113	−0.647
Most-cited publications	0.228	0.104	−0.281	−0.110	0.098	−0.186	−0.231	0.121	0.323	0.368	−0.066	0.209	0.446	0.376	0.182	0.067	0.116	0.144	0.103	−0.077	−0.133	−0.020
Digital skills	0.208	−0.174	−0.376	−0.225	−0.169	−0.059	0.021	0.021	0.269	−0.075	−0.170	−0.292	−0.112	−0.226	−0.024	0.034	0.474	−0.282	−0.014	0.346	0.098	−0.102
R&D expenditures public sector	0.237	0.021	−0.033	0.115	−0.176	−0.413	0.440	−0.062	−0.121	−0.278	0.056	−0.121	0.361	−0.180	0.161	−0.288	0.033	0.348	0.146	−0.041	0.059	0.018
R&D expenditures business sector	0.257	−0.168	0.094	−0.155	−0.103	0.317	0.113	−0.027	−0.083	0.000	0.303	−0.086	0.521	0.072	−0.170	−0.056	−0.223	−0.274	−0.363	0.196	−0.169	−0.104
Non-R&D innovation expenditures	0.018	0.393	0.210	0.085	0.093	0.051	0.380	0.398	0.273	−0.361	−0.041	−0.169	−0.023	0.323	0.064	0.298	0.074	−0.166	−0.017	0.007	−0.114	0.029
Innovation expenditures per person employed	0.222	0.149	0.096	0.203	−0.070	0.260	−0.063	0.549	0.162	0.198	−0.205	0.129	0.009	−0.398	−0.016	−0.265	−0.250	0.079	0.103	0.201	0.157	−0.061
IT specialists	0.221	−0.244	0.024	0.262	0.025	0.150	0.032	−0.324	0.193	−0.214	−0.457	0.149	−0.023	0.100	0.285	−0.219	−0.176	−0.364	0.094	−0.206	−0.159	−0.002
Product process innovators	0.241	0.286	0.052	−0.125	−0.091	0.035	−0.124	−0.257	−0.297	−0.075	−0.186	−0.022	−0.124	0.248	−0.030	0.078	−0.187	0.135	0.351	0.574	−0.157	−0.086
Business process innovators	0.237	0.341	0.072	−0.091	0.001	−0.086	−0.024	−0.136	−0.181	0.084	−0.204	−0.021	0.016	0.200	−0.039	−0.081	0.008	−0.181	−0.301	−0.168	0.707	−0.079
Innovative SMEs collaborating with others	0.231	0.232	−0.063	0.107	−0.178	0.255	−0.292	−0.106	−0.116	−0.043	0.205	−0.241	0.059	−0.319	0.487	0.409	0.006	0.010	0.019	−0.231	−0.014	0.072

Table A2. *Cont.*

Eigenvectors:																						
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22
Public–private co-publications	0.292	−0.066	−0.040	0.208	0.083	−0.208	0.212	−0.026	−0.078	0.272	0.123	0.160	−0.121	−0.050	−0.067	0.203	−0.053	−0.232	−0.009	0.179	0.025	0.705
PCT patent applications	0.277	−0.082	−0.056	−0.354	−0.077	0.099	0.114	0.120	−0.022	−0.026	0.268	0.058	−0.142	0.045	−0.249	−0.003	−0.101	−0.187	0.596	−0.411	0.100	−0.070
Trademark applications	0.219	−0.165	0.013	0.015	0.507	−0.097	−0.208	−0.014	0.061	−0.181	−0.266	−0.363	0.151	−0.162	−0.395	0.260	−0.205	0.209	−0.004	−0.119	0.017	0.054
Design applications	0.137	−0.184	0.196	−0.340	0.566	0.000	−0.043	0.224	−0.284	−0.126	0.084	0.130	−0.058	−0.049	0.468	−0.154	0.181	−0.046	−0.015	0.131	0.025	0.005
Employment knowledge-intensive activities	0.187	−0.183	0.252	0.077	0.085	0.472	0.333	−0.246	0.157	0.294	−0.006	−0.074	−0.088	0.120	−0.004	0.071	0.336	0.429	0.041	0.002	0.130	−0.027
Employment in innovative SMEs	0.257	0.271	0.090	−0.139	−0.072	−0.026	−0.013	0.061	−0.221	0.163	−0.203	−0.094	−0.190	−0.091	−0.196	−0.268	0.271	0.027	−0.249	−0.309	−0.551	0.085
Sales of new-to-market and new-to-firm innovations	0.152	0.327	−0.025	0.185	0.266	0.043	−0.247	−0.271	0.360	−0.257	0.471	0.111	−0.096	−0.051	−0.169	−0.357	0.144	0.000	−0.009	0.094	0.012	0.042
N. of Universities	0.115	−0.146	0.507	−0.011	−0.302	−0.129	−0.277	0.028	0.032	−0.267	−0.083	0.442	0.169	−0.097	−0.182	0.251	0.332	0.017	0.016	0.007	0.045	0.033
Total Academic Personnel (FTE)	0.128	−0.160	0.435	−0.200	−0.199	−0.353	−0.141	−0.021	0.381	0.169	0.154	−0.325	−0.276	0.089	0.205	−0.089	−0.300	0.058	−0.111	0.026	−0.016	−0.006

Factor Loadings:																						
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22
Population with tertiary education	0.362	−0.523	−0.062	0.524	−0.130	0.022	−0.274	0.272	−0.203	−0.047	0.080	−0.184	−0.034	0.228	−0.020	−0.078	0.077	0.001	0.021	−0.001	0.015	0.006
Lifelong learning	0.640	−0.253	−0.505	−0.205	−0.180	0.135	0.006	0.114	0.042	−0.242	0.004	0.169	−0.161	0.082	0.013	0.027	−0.084	0.144	−0.117	−0.011	0.008	0.024
International scientific co-publications	0.805	−0.114	−0.090	0.371	0.135	−0.265	0.132	0.007	−0.068	0.091	0.101	0.129	−0.129	−0.040	−0.011	0.115	−0.015	−0.021	−0.044	0.001	−0.024	−0.110
Most-cited publications	0.677	0.187	−0.385	−0.123	0.101	−0.181	−0.204	0.105	0.235	0.250	−0.041	0.126	0.242	0.197	0.087	0.028	0.047	0.052	0.032	−0.019	−0.028	−0.003
Digital skills	0.618	−0.313	−0.515	−0.252	−0.176	−0.058	0.018	0.018	0.196	−0.051	−0.105	−0.176	−0.061	−0.118	−0.011	0.014	0.190	−0.102	−0.004	0.088	0.021	−0.017
R&D expenditures public sector	0.703	0.037	−0.046	0.129	−0.183	−0.401	0.390	−0.054	−0.088	−0.189	0.035	−0.073	0.196	−0.095	0.077	−0.120	0.013	0.126	0.045	−0.010	0.013	0.003
R&D expenditures business sector	0.763	−0.302	0.129	−0.173	−0.107	0.307	0.100	−0.023	−0.060	0.000	0.188	−0.052	0.283	0.038	−0.081	−0.023	−0.089	−0.099	−0.111	0.050	−0.036	−0.018
Non-R&D innovation expenditures	0.054	0.707	0.287	0.095	0.097	0.049	0.337	0.345	0.199	−0.245	−0.025	−0.102	−0.012	0.170	0.031	0.125	0.030	−0.060	−0.005	0.002	−0.024	0.005
Innovation expenditures per person employed	0.660	0.267	0.132	0.227	−0.073	0.253	−0.056	0.475	0.118	0.135	−0.127	0.078	0.005	−0.209	−0.007	−0.111	−0.100	0.029	0.032	0.051	0.033	−0.010
IT specialists	0.658	−0.439	0.033	0.294	0.026	0.145	0.029	−0.281	0.140	−0.145	−0.283	0.090	−0.013	0.052	0.136	−0.092	−0.071	−0.131	0.029	−0.052	−0.034	0.000
Product process innovators	0.715	0.515	0.071	−0.140	−0.094	0.034	−0.110	−0.223	−0.216	−0.051	−0.116	−0.013	−0.067	0.130	−0.014	0.033	−0.075	0.049	0.108	0.145	−0.034	−0.015
Business process innovators	0.704	0.614	0.098	−0.102	0.001	−0.083	−0.021	−0.118	−0.132	0.057	−0.127	−0.013	0.009	0.105	−0.019	−0.034	0.003	−0.065	−0.092	−0.043	0.151	−0.013
Innovative SMEs collaborating with others	0.687	0.417	−0.087	0.120	−0.185	0.248	−0.259	−0.092	−0.084	−0.029	0.127	−0.145	0.032	−0.167	0.232	0.171	0.002	0.004	0.006	−0.058	−0.003	0.012
Public–private co-publications	0.869	−0.119	−0.055	0.233	0.087	−0.201	0.188	−0.023	−0.057	0.185	0.076	0.097	−0.065	−0.026	−0.032	0.085	−0.021	−0.084	−0.003	0.045	0.005	0.120
PCT patent applications	0.823	−0.147	−0.077	−0.396	−0.080	0.096	0.101	0.104	−0.016	−0.018	0.167	0.035	−0.077	0.024	−0.119	−0.001	−0.041	−0.067	0.182	−0.104	0.021	−0.012
Trademark applications	0.650	−0.298	0.017	0.016	0.528	−0.094	−0.185	−0.012	0.045	−0.123	−0.165	−0.219	0.082	−0.085	−0.188	0.109	−0.082	0.075	−0.001	−0.030	0.004	0.009
Design applications	0.409	−0.331	0.269	−0.381	0.588	0.000	−0.038	0.194	−0.207	−0.085	0.052	0.078	−0.032	−0.026	0.223	−0.064	0.072	−0.016	−0.005	0.033	0.005	0.001
Employment knowledge-intensive activities	0.556	−0.329	0.345	0.087	0.088	0.458	0.295	−0.213	0.114	0.200	−0.004	−0.044	−0.048	0.063	−0.002	0.030	0.135	0.155	0.013	0.000	0.028	−0.005
Employment in innovative SMEs	0.764	0.488	0.124	−0.155	−0.075	−0.025	−0.012	0.053	−0.161	0.111	−0.126	−0.057	−0.103	−0.048	−0.093	−0.112	0.109	0.010	−0.076	−0.078	−0.118	0.015
Sales of new-to-market and new-to-firm innovations	0.451	0.589	−0.034	0.207	0.277	0.042	−0.219	−0.234	0.262	−0.174	0.292	0.067	−0.052	−0.027	−0.081	−0.149	0.058	0.000	−0.003	0.024	0.003	0.007
N. of Universities	0.343	−0.263	0.695	−0.012	−0.315	−0.126	−0.246	0.024	0.023	−0.181	−0.052	0.266	0.092	−0.051	−0.087	0.105	0.133	0.006	0.005	0.002	0.010	0.006
Total Academic Personnel (FTE)	0.381	−0.288	0.597	−0.224	−0.207	−0.343	−0.125	−0.018	0.277	0.115	0.095	−0.196	−0.150	0.047	0.098	−0.037	−0.120	0.021	−0.034	0.007	−0.003	−0.001

Correlations Between Variables and Factors:																						
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22
Population with tertiary education	0.362	−0.523	−0.062	0.524	−0.130	0.022	−0.274	0.272	−0.203	−0.047	0.080	−0.184	−0.034	0.228	−0.020	−0.078	0.077	0.001	0.021	−0.001	0.015	0.006
Lifelong learning	0.640	−0.253	−0.505	−0.205	−0.180	0.135	0.006	0.114	0.042	−0.242	0.004	0.169	−0.161	0.082	0.013	0.027	−0.084	0.144	−0.117	−0.011	0.008	0.024
International scientific co-publications	0.805	−0.114	−0.090	0.371	0.135	−0.265	0.132	0.007	−0.068	0.091	0.101	0.129	−0.129	−0.040	−0.011	0.115	−0.015	−0.021	−0.044	0.001	−0.024	−0.110
Most-cited publications	0.677	0.187	−0.385	−0.123	0.101	−0.181	−0.204	0.105	0.235	0.250	−0.041	0.126	0.242	0.197	0.087	0.028	0.047	0.052	0.032	−0.019	−0.028	−0.003
Digital skills	0.618	−0.313	−0.515	−0.252	−0.176	−0.058	0.018	0.018	0.196	−0.051	−0.105	−0.176	−0.061	−0.118	−0.011	0.014	0.190	−0.102	−0.004	0.088	0.021	−0.017
R&D expenditures public sector	0.703	0.037	−0.046	0.129	−0.183	−0.401	0.390	−0.054	−0.088	−0.189	0.035	−0.073	0.196	−0.095	0.077	−0.120	0.013	0.126	0.045	−0.010	0.013	0.003
R&D expenditures business sector	0.763	−0.302	0.129	−0.173	−0.107	0.307	0.100	−0.023	−0.060	0.000	0.188	−0.052	0.283	0.038	−0.081	−0.023	−0.089	−0.099	−0.111	0.050	−0.036	−0.018
Non-R&D innovation expenditures	0.054	0.707	0.287	0.095	0.097	0.049	0.337	0.345	0.199	−0.245	−0.025	−0.102	−0.012	0.170	0.031	0.125	0.030	−0.060	−0.005	0.002	−0.024	0.005
Innovation expenditures per person employed	0.660	0.267	0.132	0.227	−0.073	0.253	−0.056	0.475	0.118	0.135	−0.127	0.078	0.005	−0.209	−0.007	−0.111	−0.100	0.029	0.032	0.051	0.033	−0.010
IT specialists	0.658	−0.439	0.033	0.294	0.026	0.145	0.029	−0.281	0.140	−0.145	−0.283	0.090	−0.013	0.052	0.136	−0.092	−0.071	−0.131	0.029	−0.052	−0.034	0.000
Product process innovators	0.715	0.515	0.071	−0.140	−0.094	0.034	−0.110	−0.223	−0.216	−0.051	−0.116	−0.013	−0.067	0.130	−0.014	0.033	−0.075	0.049	0.108	0.145	−0.034	−0.015
Business process innovators	0.704	0.614	0.098	−0.102	0.001	−0.083	−0.021	−0.118	−0.132	0.057	−0.127	−0.013	0.009	0.105	−0.019	−0.034	0.003	−0.065	−0.092	−0.043	0.151	−0.013
Innovative SMEs collaborating with others	0.687	0.417	−0.087	0.120	−0.185	0.248	−0.259	−0.092	−0.084	−0.029	0.127	−0.145	0.032	−0.167	0.232	0.171	0.002	0.004	0.006	−0.058	−0.003	0.012
Public–private co-publications	0.869	−0.119	−0.055	0.233	0.087	−0.201	0.188	−0.023	−0.057	0.185	0.076	0.097	−0.065	−0.026	−0.032	0.085	−0.021	−0.084	−0.003	0.045	0.005	0.120
PCT patent applications	0.823	−0.147	−0.077	−0.396	−0.080	0.096	0.101	0.104	−0.016	−0.018	0.167	0.035	−0.077	0.024	−0.119	−0.001	−0.041	−0.067	0.182	−0.104	0.021	−0.012
Trademark applications	0.650	−0.298	0.017	0.016	0.528	−0.094	−0.185	−0.012	0.045	−0.123	−0.165	−0.219	0.082	−0.085	−0.188	0.109	−0.082	0.075	−0.001	−0.030	0.004	0.009

Correlations Between Variables and Factors:

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22
Design applications	0.409	−0.331	0.269	−0.381	0.588	0.000	−0.038	0.194	−0.207	−0.085	0.052	0.078	−0.032	−0.026	0.223	−0.064	0.072	−0.016	−0.005	0.033	0.005	0.001
Employment knowledge-intensive activities	0.556	−0.329	0.345	0.087	0.088	0.458	0.295	−0.213	0.114	0.200	−0.004	−0.044	−0.048	0.063	−0.002	0.030	0.135	0.155	0.013	0.000	0.028	−0.005
Employment in innovative SMEs	0.764	0.488	0.124	−0.155	−0.075	−0.025	−0.012	0.053	−0.161	0.111	−0.126	−0.057	−0.103	−0.048	−0.093	−0.112	0.109	0.010	−0.076	−0.078	−0.118	0.015
Sales of new-to-market and new-to-firm innovations	0.451	0.589	−0.034	0.207	0.277	0.042	−0.219	−0.234	0.262	−0.174	0.292	0.067	−0.052	−0.027	−0.081	−0.149	0.058	0.000	−0.003	0.024	0.003	0.007
N. of Universities	0.343	−0.263	0.695	−0.012	−0.315	−0.126	−0.246	0.024	0.023	−0.181	−0.052	0.266	0.092	−0.051	−0.087	0.105	0.133	0.006	0.005	0.002	0.010	0.006
Total Academic Personnel (FTE)	0.381	−0.288	0.597	−0.224	−0.207	−0.343	−0.125	−0.018	0.277	0.115	0.095	−0.196	−0.150	0.047	0.098	−0.037	−0.120	0.021	−0.034	0.007	−0.003	−0.001

Factor Scores:

Observation	F1	F2
Région de Bruxelles-Capitale	4.686	0.854
Vlaams Gewest	4.328	0.759
Région wallonne	2.580	1.171
Praha	2.669	−2.259
Střední Cechy	−0.025	1.434
Jihozápad	−1.476	0.576
Severozápad	−4.609	0.671
Severovýchod	−1.175	1.125
Jihovýchod	0.041	0.540
Střední Morava	−1.563	0.477
Moravskoslezsko	−1.381	1.592
Hovedstaden	6.710	−2.163
Sjælland	0.892	0.823
Syddanmark	2.160	−0.837
Midtjylland	4.496	−0.429
Nordjylland	3.191	0.135
Northern and Western	0.186	0.185
Southern	0.906	1.455
Eastern and Midland	2.289	−0.965
Attiki	1.519	1.937
Voreio Aigaio	−1.525	3.407
Notio Aigaio	−3.947	2.664
Kriti	0.726	4.813
Anatoliki Makedonia, Thraki	−2.339	2.969
Kentriki Makedonia	0.496	3.496
Dytiki Makedonia	−3.481	1.873
Ipeiros	−0.742	2.801
Thessalia	−0.401	4.035
Ionia Nisia	−2.710	4.591
Dytiki Ellada	−0.515	3.806
Sterea Ellada	−2.203	3.822
Peloponnisos	−2.553	3.235
Galicia	−1.807	−1.311
Principado de Asturias	−2.254	−1.642
Cantabria	−2.163	−1.645
País Vasco	1.042	−1.279
Comunidad Foral de Navarra	0.121	−1.643
La Rioja	−1.659	−1.218
Aragón	−1.600	−1.492
Comunidad de Madrid	0.895	−3.352
Castilla y León	−2.133	−0.843
Castilla-la Mancha	−3.398	−1.121
Extremadura	−3.833	−0.419
Cataluña	0.774	−2.386
Comunitat Valenciana	−0.429	−2.116
Illes Balears	−3.063	−2.110
Andalucía	−2.556	−1.589
Región de Murcia	−2.008	−1.329
Canarias	−4.539	−2.171
Île de France	4.649	−2.939
Centre–Val de Loire	−0.883	0.256
Bourgogne–Franche-Comté	−0.800	−0.222
Normandie	−1.891	−0.884
Hauts-de-France	−1.029	−1.200
Grand Est	−0.192	0.277
Pays de la Loire	0.165	−0.261
Bretagne	1.258	0.924
Nouvelle-Aquitaine	−0.316	0.223
Occitanie	2.315	−0.754
Auvergne-Rhône-Alpes	2.446	−1.052
Provence-Alpes-Côte d'Azur	0.972	−0.044
Corse	−5.220	−1.338
Régions ultrapériphériques françaises	−3.089	3.026
Piemonte	1.684	1.829
Valle d'Aosta/Vallée d'Aoste	−3.292	0.359
Liguria	−0.733	0.580
Lombardia	2.534	1.088
Provincia Autonoma Bolzano/Bozen	1.148	3.111
Provincia Autonoma Trento	2.592	2.657
Veneto	2.340	2.017
Friuli-Venezia Giulia	2.284	2.081
Emilia-Romagna	2.832	1.620
Toscana	2.003	2.001
Umbria	1.476	1.843
Marche	0.223	1.554
Lazio	1.795	1.323
Abruzzo	−0.279	2.508

Factor Scores:		
Observation	**F1**	**F2**
Molise	−0.289	2.242
Campania	−0.247	2.694
Puglia	−1.204	2.354
Basilicata	−1.047	3.206
Calabria	−2.096	3.040
Sicilia	−1.787	3.251
Sardegna	−1.438	1.857
Sostinės regionas	1.700	0.503
Vidurio ir vakarų Lietuvos regionas	−2.308	1.343
Budapest	1.283	−2.585
Pest	−2.652	−1.071
Közép-Dunántúl	−3.494	−0.587
Nyugat-Dunántúl	−3.967	−0.232
Dél-Dunántúl	−4.289	−0.389
Észak-Magyarország	−4.380	−0.220
Észak-Alföld	−4.115	−0.829
Dél-Alföld	−3.463	−0.034
Groningen	2.381	−1.001
Friesland	0.173	−0.017
Drenthe	−0.214	−0.255
Overijssel	1.977	−1.154
Gelderland	3.102	−1.704
Flevoland	1.431	−1.200
Utrecht	3.742	−2.370
Noord-Holland	3.785	−2.544
Zuid-Holland	3.355	−1.933
Zeeland	−0.067	0.128
Noord-Brabant	3.592	−2.525
Limburg	3.151	−1.518
Ostösterreich	4.667	−0.589
Südösterreich	3.773	−0.392
Westösterreich	3.422	−0.317
Malopolskie	−1.641	−2.620
Slaskie	−3.963	−2.623
Wielkopolskie	−3.820	−2.771
Zachodniopomorskie	−4.769	−2.080
Lubuskie	−4.844	−1.521
Dolnoslaskie	−2.650	−2.842
Opolskie	−4.446	−1.781
Kujawsko-Pomorskie	−4.357	−1.234
Warminsko-Mazurskie	−5.248	−1.068
Pomorskie	−2.846	−2.695
Lódzkie	−3.739	−2.403
Swietokrzyskie	−5.432	−1.982
Lubelskie	−3.972	−1.134
Podkarpackie	−3.721	−1.603
Podlaskie	−4.539	−1.355
Warszawski stoleczny	0.426	−4.460
Mazowiecki regionalny	−5.893	−1.283
Norte	−0.198	−1.336
Algarve	−3.210	−0.755
Centro	−0.554	0.092
Lisboa	1.211	−1.817
Alentejo	−2.249	0.682
Região Autónoma dos Açores	−4.016	0.482
Região Autónoma da Madeira	−3.302	−0.880
Vzhodna Slovenija	−0.113	−0.512
Zahodna Slovenija	2.222	−1.811
Bratislavský kraj	0.241	−2.495
Západné Slovensko	−3.594	−1.250
Stredné Slovensko	−3.314	−0.038
Vachon Slovensko	−3.571	−0.491
Helsinki-Uusimaa	7.483	−1.144
Etelä-Suomi	3.375	−0.320
Länsi-Suomi	4.813	0.506
Pohjois-ja Itä-Suomi	3.551	0.758
Åland	0.045	−0.109
Stockholm	7.334	−1.530
Östra Mellansverige	4.946	−1.268
Småland med öarna	1.810	0.442
Sydsverige	5.919	−0.595
Västsverige	5.469	−1.064
Norra Mellansverige	0.823	−0.166
Mellersta Norrland	0.714	0.481
Övre Norrland	3.139	0.561
Baden-Württemberg	5.265	−1.449
Bavaria	3.613	−0.994
Berlin	5.563	−0.198
Brandenburg	0.402	2.231
Bremen	2.337	0.396
Hamburg	4.457	−0.162
Hesse	2.814	0.410
Mecklenburg-Vorpommern	−0.061	1.790
Lower Saxony	1.926	0.548
North Rhine-Westphalia	3.578	−1.058
Rhineland-Palatinate	1.875	0.819
Saarland	1.436	0.667
Saxony	2.287	1.851
Sachsen-Anhalt	−0.088	2.614
Schleswig-Holstein	1.641	0.987
Thüringen	1.353	1.917

Regression of Variable EIS:	
Goodness of fit statistics:	
Observations	168.000
Sum of weights	168.000
DF	145.000
R^2	0.983
Adjusted R^2	0.980
MSE	15.021
RMSE	3.876
MAPE	3.376
DW	1.002
Cp	23.000
AIC	476.455
SBC	548.306
PC	0.023
Press RMSE	3218.472

Analysis of Variance:

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	22	123,482.291	5612.831	373.662	<0.0001
Error	145	2178.068	15.021		
Corrected Total	167	125,660.359			

Computed against model Y = Mean(Y)

Model Parameters for the Components:

Source	Value	Standard Error	t	Pr > |t|	Lower Bound (95%)	Upper Bound (95%)
Intercept	89.178	0.299	298.236	<0.0001	88.587	89.769
F1	9.000	0.101	89.477	<0.0001	8.802	9.199
F2	−1.108	0.166	−6.666	<0.0001	−1.437	−0.780
F3	−1.514	0.218	−6.941	<0.0001	−1.945	−1.083
F4	−1.189	0.267	−4.451	<0.0001	−1.717	−0.661
F5	−0.897	0.287	−3.122	0.002	−1.465	−0.329
F6	0.861	0.308	2.793	0.006	0.252	1.470
F7	1.222	0.337	3.623	0.000	0.555	1.888
F8	1.530	0.345	4.434	<0.0001	0.848	2.212
F9	1.628	0.411	3.965	0.000	0.817	2.440
F10	−0.790	0.440	−1.796	0.075	−1.660	0.080
F11	−1.125	0.482	−2.336	0.021	−2.078	−0.173
F12	−0.098	0.496	−0.197	0.844	−1.078	0.883
F13	0.468	0.551	0.850	0.397	−0.621	1.558
F14	1.122	0.570	1.968	0.051	−0.005	2.249
F15	1.464	0.627	2.334	0.021	0.224	2.704
F16	0.369	0.714	0.517	0.606	−1.042	1.780
F17	1.655	0.746	2.218	0.028	0.180	3.130
F18	−1.437	0.829	−1.735	0.085	−3.075	0.200
F19	0.377	0.977	0.386	0.700	−1.553	2.307
F20	−1.363	1.182	−1.153	0.251	−3.698	0.972
F21	3.725	1.402	2.657	0.009	0.954	6.496
F22	1.075	1.753	0.613	0.541	−2.390	4.540

Model Parameters for the Input Variables:

Source	Value	Standard Error	t	Pr > |t|	Lower Bound (95%)	Upper Bound (95%)
Intercept	2.578	7.987	0.323	0.747	−13.209	18.365
Population with tertiary education	6.771	1.880	3.601	0.000	3.054	10.487
Lifelong learning	11.503	2.462	4.673	<0.0001	6.638	16.369
International scientific co-publications	1.377	5.324	0.259	0.796	−9.146	11.900
Most-cited publications	15.457	2.712	5.700	<0.0001	10.097	20.817
Digital skills	20.001	3.120	6.411	<0.0001	13.835	26.167
R&D expenditures public sector	9.744	2.312	4.215	<0.0001	5.175	14.313
R&D expenditures business sector	6.236	2.962	2.105	0.037	0.381	12.090
Non-R&D innovation expenditures	10.810	3.082	3.507	0.001	4.718	16.902
Innovation expenditures per person employed	10.961	3.104	3.531	0.001	4.826	17.096
IT specialists	11.100	2.317	4.791	<0.0001	6.520	15.679
Product process innovators	−1.520	3.713	−0.409	0.683	−8.860	5.819
Business process innovators	15.183	3.772	4.026	<0.0001	7.729	22.638
Innovative SMEs collaborating with others	8.981	2.463	3.647	0.000	4.113	13.849
Public–private co-publications	11.861	5.697	2.082	0.039	0.601	23.121
PCT patent applications	17.154	3.555	4.825	<0.0001	10.127	24.181
Trademark applications	4.531	2.576	1.759	0.081	−0.559	9.622
Design applications	7.599	2.073	3.666	0.000	3.502	11.696
Employment knowledge-intensive activities	9.581	2.267	4.226	<0.0001	5.100	14.061
Employment in innovative SMEs	0.390	3.590	0.109	0.914	−6.705	7.486
Sales of new-to-market and new-to-firm innovations	−0.729	2.572	−0.283	0.777	−5.813	4.355
N. of Universities	8.395	3.449	2.434	0.016	1.578	15.211
Total Academic Personnel (FTE)	3.558	3.670	0.970	0.334	−3.694	10.811

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