The impact of patent applications on technological innovation in European countries

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Abstract

We investigate the innovational determinants of "*Patent Applications*" in Europe. We use data from the European Innovation Scoreboard-EIS of the European Commission for 36 countries in the period 2010-2019. We use Panel Data with Fixed Effects, Panel Data with Random Effects, Pooled OLS, WLS and Dynamic Panel. We found that the variables that have a deeper positive association with "*Patent Applications*" are "*Human Resources*" and "*Intellectual Assets*", while the variables that show a more intense negative relation with Patent Applications are "*Employment Share in Manufacturing*" and "*Total Entrepreneurial Activity*". A cluster analysis with the k-Means algorithm optimized with the Silhouette Coefficient has been realized. The results show the presence of two clusters. A network analysis with the distance of Manhattan has been performed and we find three different complex network structures. Finally, a comparison is made among eight machine learning algorithms for the prediction of the future value of the "*Patent Applications*". We found that PNN-Probabilistic Neural Network is the best performing algorithm. Using PNN the results show that the mean future value of "*Patent Applications*" in the estimated countries is expected to decrease of -0.1%.

Keywords: Innovation, and Invention: Processes and Incentives; Management of Technological Innovation and R&D; Diffusion Processes; Open Innovation.

JEL Classification: O30; O31, O32; O33; O36.

1. Introduction-Research Question

In the following article we analyze the issues related to industrial patents in Europe. The analysis presented is essentially of a metric nature. The choice of analytical methodologies was due to the need to identify the presence of econometric relationships in the multivariate model, to verify the existence of clusters and network structures and to predict the future trend of the variable for the countries considered using machine learning algorithms.
The choice of the theme, namely patents, is essential in the current socio-political and international economic context. In fact, the knowledge economy, cognitive capitalism, the information society have created a very strong competition among countries to have more and more patents. In this sense, two

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blocs of countries are substantially geographically opposed: on the one hand the United States and on the other the Asian countries with China, Japan, and South Korea. The role of Europe, on the other hand, appears to be completely marginal and the old continent seems truly backward in the competition of knowledge, in the tech-war that inevitably involves China and the USA, on various fronts, such as for example on the issue of micro-chips.
The same econometric analysis carried out in the article shows how even investment in human capital is not enough to increase the registration of patents because obviously without large companies operating in high-tech sectors it is very difficult to carry out patenting activities. It follows that the entrepreneurial structure of European industry, apart from a few geographically determined exceptions, appears to be largely backward and lacks the necessary capacity to compete on an equal footing with the US and China. It is therefore necessary to intervene with economic policies and with a reform of economic institutions to also give incentives to companies that propose patents and make sure that the connection between the public-private research system and profit-oriented companies is more stringent and oriented to the creation of new patents. The ingenuity of Europeans and their ability to profit from scientific and technological works seem truly far behind in knowledge-intensive areas in respect to more competitive countries and technological powers such as the US and China.

2. Literature Review

Below is a brief analysis of the literature that serves to frame the issues relating to the role of patents in promoting technological innovation, research and development and economic growth. Obviously at this juncture it was decided to avoid mentioning the age-old question relating to the hypothesis of free patenting, as there are in fact some economists who have railed against copyright [1]. On the contrary, we have assumed that patent rights play a role in promoting technological innovation and economic growth, while also highlighting how any further restrictions in patent law could have socially adverse effects such as those related to growth of income inequality.
[2] refer to the use of industrial patenting in the biotechnology sector with reference to the following countries namely: Chile, Mexico, Argentina, Brazil, and Cuba. The analyzed period is between 1999 and 2015. The authors are particularly wondered if it exists if it exists A relationship between research in research and development as a percentage of GDP and the value of industrial patents at national level. The results show that there is a positive relationship between research in research and development as a percentage of GDP and the number of industrial patents in the biotechnology sector. [3] analyze the presence of a relationship between expenditure on research and development, industrial patents, and the impact on the export of high-tech products. The authors used data from 52 countries in the period between 2007 and 2018. The results show that the 1% growth in the number of patent applications increases exports of high-tech products by 0.01%. [4] identify the presence of a long-term relationship between trademarks and patents using data between 1977 and 2016. The results show that trademarks and patents are cointegrated and have the same attributes in terms of distribution, seasonal variations, and short-term cross- periodicity. [5] consider the role of patent applications in the medical sector in India. At present the number of Indian patent applications in the medical sector are growing. However, the number of Indian patent applications is approximately 17% of the total worldwide value. The authors expect a significant growth in Indian patent applications and expect production in terms of value equivalent to an amount of 50 billion dollars by 2025.
[6] analyze the various forms of technological innovation distinguishing between individual inventions and organizational inventions or inventions made within organizations such as universities or companies. The author considers both developing countries and developed countries in the period between 2013 and 2015. The results show that the countries in which individual patenting is more widespread have an

overall reduced level of economic development. On the contrary, the countries in which the organizations carry out the innovations have a higher level of economic progress. Individual patenting is simply considered as a sign of the presence of untapped innovative potential. [7] analyze the relationship between the increase in research and development spending and the increase in the number of license applications. The author verifies that the 10% increase in expenditure in terms of R&D creates growth between 1.52 and 2.04% of the applications appliances per 100 scientists. [8] analyzes the relationship between investment cuts in public universities and the impact on the production of patents by the universities themselves. The author shows that divestment by public universities led to a reduction in the number of patents and to a reduction in the salary for researchers and staff. [9] apply a qualitative indicator to measure the level of the quality of the license in China by distinguishing the citations in foreign, domestic, and self-citations. The authors verify that using foreign citations, the quality of the license in China is approximately 1/3 of the corresponding value for other countries. However, using domestic citations and self-citations is a higher value for the quality of the license. However, the authors conclude that domestic and self-citations should not be used as these can generate false results and attribute to the quality of Chinese licenses a value higher than the real one especially in an international comparison. [10] analyze the relationship between industrial property patents and academic patents in Brazil. The authors verify that most patents in the high -intensity sectors of scientific research are owned by the university with a value of approximately 66.1% while the component owned by non -university entities is 33.9%

[11] analyze the relationship between the presence of members of the Communist Party on the board of Chinese companies and patent applications. The authors show that the presence of Chinese Communist Party members on the board of Chinese companies tends to increase the likelihood of patent infringement and reduces the number of patent applications. [12] consider the negative impact that technological innovations have in the financial sector through the development of new patents. The authors point out that to resist this destructive trend it is necessary for companies operating in the finance sector to make abundant investments in technology to defend themselves from the destructive competition of fintech startups. [13] highlight the relationship between environmental patents and economic growth at the country level. [14] analyze the relationship between the recognition of patents produced by universities and the gross domestic product on a regional basis. The authors verify that the gross domestic product calculated on a regional basis has a positive impact on the production of patents from university products even if the inverse relationship is not verified. Furthermore, the impact of regional GDP on the ability of universities to apply for patents tends to be higher in Beijing and in the southern regions than in other regions of China. [15] show the role of eco-patents in reducing CO_2 emissions in OECD countries. [16] refer to the role that restrictions on patent law play in promoting economic growth and income inequality. Furthermore, it is necessary to consider the presence of gender discrimination found in the USA in the obtaining and conservation of patents [17].

3. The Econometric Model for the Estimation of the Economic and Innovational Determinants of Patents

An econometric analysis is proposed below to investigate the relationships existing between industrial patents and some variables that are part of the European Innovation Scoreboard-EIS of the European Commission. The aim is to verify, in the context of the multivariate analysis, which are the elements that positively or negatively affect the determination of industrial patents. In particular, the following econometric models have been used: Dynamic Panel, Pooled OLS, Panel Data with Fixed Effects, Panel Data with Random Effects, WLS. The data analyzed refer to 36 European countries for a period between 2010 and 2019.

In particular we have estimated the following equation:

$$\begin{aligned}
\boldsymbol{PatentApplications_{it}} &= \boldsymbol{a_1 + b_1(EmploymentShareManufacturing)_{it}} \\
&+ \boldsymbol{b_2(ForeignControlledEnterprisesShareOfValueAdded)_{it}} \\
&+ \boldsymbol{b_3(HumanResources)_{it} + b_4(IntellectualAssets)_{it}} \\
&+ \boldsymbol{b_5(KnowledgeIntensiveServicesExports)_{it} + b_6(Linkages)_{it}} \\
&+ \boldsymbol{b_7(NewDoctorateGraduates)_{it}} \\
&+ \boldsymbol{b_8(OpportunityDrivenEntrepreneurship)_{it}} \\
&+ \boldsymbol{b_9(PrivateCoFundingOfPublicRAndDExpenditures)_{it}} \\
&+ \boldsymbol{b_{10}(RAndDExpenditureBusinessSector)_{it} + b_{11}(TertiaryEducation)_{it}} \\
&+ \boldsymbol{b_{12}(TotalEntrepreneurialActivity)_{it} + b_{13}(TrademarkApplications)_{it}} \\
&+ \boldsymbol{b_{14}(TurnoverShareSMEs)_{it}}
\end{aligned}$$

$i = 36$[4] $t = [2010{:}\,2019]$.

Specifically, we found that the variable Patent Applications is positively associated with:

- *Human Resources* [18]*:* is a variable consisting of the sum of the following sub-variables, namely "*New Doctorate Graduates*" [19] , "*Population Aged 25-34 With Tertiary Education*", "*Lifelong Learning*" [20]. There is a positive relationship between the value of the Patent Applications variable and the value of the "Human Resources" variable. This relationship can be better understood considering that the development of human capital is necessary to develop Patent Applications. In fact, patents are the result of the creativity, ingenuity, and technical-scientific ability of human capital, applied to technological innovations, inventions and research and development. It follows that if a country intends to increase its patent production capacity, then it can invest in the development of human capital. In this sense, it is also possible to create institutional relations between companies, university research institutions and private research bodies, to generate positive effects in terms of patenting and the possibility of industrialization of patents.
- *Intellectual Assets:* Intellectual assets [21] is a variable consisting of the following sub-variables, namely "*PCT Patent Applications*", "*Trademark Applications*", "*Design Applications*" [22]. There is a positive relationship between the value of Patent Applications and the value of Intellectual Assets. This relationship is since patents are defined, within the European Innovation Scoreboard-EIS database, as a component of Intellectual Assets. However, it is obvious that the possibility of developing patents also depends on the ability of an economic system to develop "*Design Applications"* and "*Trademark Applications*" as well. In fact, these components are the product of a similar creativity and ingenuity applied to technological innovation and research and development. It follows that if a country wants to increase its ability to produce patents it must also invest significantly in "*Design Applications*" and "*Trademark Applications*".
- *Turnover Share SMEs:* is a variable that takes into consideration the value of the turnover of small and medium-sized enterprises or enterprises that have a number of employees between 10 and 249 people. There is a positive relationship between the development of patents and the growth of the turnover of small and medium-sized enterprises. new products and services. A dynamic economy, oriented towards the knowledge economy, which therefore generates

[4] Countries are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, UK.

inventions and innovations, recognized through patents, can lead to a greater production capacity which is therefore translated into greater sales and turnover even for small and medium-sized enterprises.

- *Knowledge-Intensive Services Exports:* considers the export value of knowledge-intensive services as a percentage of total exports [23]. This indicator measures the competitiveness of the knowledge-intensive services sector. This value therefore measures the ability of a country to be competitive and innovative in the international context through the development of advanced services from the point of view of knowledge. There is a positive relationship between the export value of knowledge-intensive services and the development of industrial patents, which is tautological. In fact, the development of industrial patents is necessary for the development of knowledge-intensive services that are generally produced because of the innovations and inventions produced through works of ingenuity and creativity.
- *Private Co-Funding of Public R&D Expenditures:* considers the private co-financing of public R&D expenditure as a percentage of GDP. It is therefore a variable that calculates the value of R&D expenditure that is financed by the private sector. It therefore contains a measurement of public-private cooperation. This private expenditure on research and development has the aim of orienting the research carried out in the university towards the needs of businesses and industry. There is a positive relationship between the development of industrial patents and the value of private R&D spending by the public sector. This relationship is since many patents that are made by companies are produced in collaboration between private companies and universities and public research centers.
- *R&D Expenditure Business Sector:* is a variable that considers R&D expenditure in the business sector as a percentage of GDP. The variable refers to the ability of private companies to invest in the creation of new knowledge. This value tends to be very high in some sectors that are closely related to scientific research such as the pharmaceutical sector, the chemical sector characterized by the fact of producing goods and services as an output of scientific activity. There is a positive relationship between the value of industrial patents and the value of private R&D spending. In fact, companies often invest in research and development with the aim of generating new products and new services. Therefore, this relationship can also be understood in a quasi-tautological sense, especially for knowledge-intensive sectors.
- *Linkages:* is a variable consisting of the following under variables i.e. innovative SMEs collaborating with others, Public-Private Co-Publications, Private Co-Funding of Public R&D Expenditures [24]. There is a positive relationship between the value of Linkages and the value of industrial patents. This relationship can be better understood considering that the technological innovation that leads to the recognition of an industrial patent is often generated precisely following collaborations and cooperations that take place between businesses. In fact, companies often collaborate in scientific publications in financing scientific research. And this collaboration often concerns both public bodies and private entities that through cooperation can increase the level of innovations and inventions by obtaining industrial patents.

Estimations of the Value of Patent Applications Using Variables from the European Innovation Scoreboard-EIS												
A40	*Patent applications*	*Dynamic Panel*		*Pooled OLS*		*Fixed Effects*		*Random Effects*		*WLS*		*Average*
		Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	
	Constat	-0,167732		-0,851697		0,0387197		-0,0646061		-0,122259		-0,23351488
A12	*Employment share Manufacturing*	-0,309482	***	-0,514046	***	-0,324907	***	-0,367754	***	-0,4998	***	-0,4031978

A20	*Foreign-controlled enterprises share of value added*	-0,220997	**	-0,153258	***	-0,115415	**	-0,123468	***	-0,103651	***	-0,1433578
A23	*Human resources*	0,437229	***	0,440667	***	0,427791	***	0,431689	***	0,484696	***	0,4444144
A29	*Intellectual assets*	0,356362	***	0,413132	***	0,351286	***	0,365005	***	0,41617	***	0,380391
A31	*Knowledge-intensive services exports*	0,133296	***	0,159265	***	0,166165	***	0,161329	***	0,171232	***	0,1582574
A33	*Linkages*	0,114188	**	0,0778794	***	0,0685645	**	0,0726235	**	0,0657994	***	0,07981096
A37	*New doctorate graduates*	-0,131717	***	-0,129864	***	-0,133389	***	-0,132162	***	-0,155676	***	-0,1365616
A39	*Opportunity-driven entrepreneurship*	-0,0371926	**	-0,0467895	***	-0,0224884	*	-0,0272749	**	-0,0259872	***	-0,03194652
A43	*Private co-funding of public R&D expenditures*	0,112665	***	0,165174	***	0,143533	***	0,149989	***	0,163626	***	0,1469974
A46	*R&D expenditure business sector*	0,143547	**	0,134517	***	0,144807	***	0,140551	***	0,104035	***	0,1334914
A53	*Tertiary education*	-0,147486	***	-0,153121	***	-0,147862	***	-0,150431	***	-0,181417	***	-0,1560634
A55	*Total Entrepreneurial Activity*	-0,566507	***	-0,417076	***	-0,439047	***	-0,423613	***	-0,529756	***	-0,4751998
A56	*Trademark applications*	-0,118842	**	-0,15797	***	-0,124353	***	-0,132408	***	-0,147489	***	-0,1362124
A58	*Turnover share SMEs*	0,286839	***	0,348121	***	0,226421	***	0,249469	***	0,341017	***	0,2903734
A40(-1)	*Patent applications*	0,0195703										

Table 1. Estimations of the Value of Patent Applications Using Variables from the European Innovation Scoreboard-EIS.

Furthermore, we found that the variable Patent Application is negatively associated with:

- *Opportunity-Driven Entrepreneurship:* is an indicator that refers to the ability of companies to carry out its business in application of the opportunities offered by the market [25]. That is, these are people who do not carry out business activities because they need them or are not entrepreneurs out of necessity. On the contrary, these are people who before doing businesses already worked as employees or as freelancers and who have turned into entrepreneurs following the identification of a set of business opportunities considered profitable. So, it is for example the case of the employee who puts himself in his own by investing resources to transform into an entrepreneur by seizing the opportunities of technological transformation. There is a negative relationship between the value of industrial patents and the value of entrepreneurs for opportunities. This negative relationship can be better understood considering that the entrepreneur for opportunities does not invest in research and development, does not accumulate industrial patents, as regards the contrary investing the resources in the opportunities already present in the market.
- *Trademark Applications:* is a variable that considers the value of trademark applications requested at the intellectual property office of the European Union and the World Intellectual-WIPI ownership office with respect to the gross domestic product. The brands are an important indicator of technological innovation in the service sector. In addition, brands are also essential because they allow companies to be recognized by consumers and allow advertising activity effectively. There is a negative relationship between the value of brands and the value of industrial

patents. This report may be since generally companies that invest in brands do not necessarily make technological innovation recognized through patents and vice versa. For example, brands are widespread in the trade sector where, however, the patent content can be very reduced. On the contrary, companies that invest a lot in patenting may also not have a brand policy, because they do not carry out Business to Customers-B2C, but at the contrary, they operate in the context of Business to Business-B2B.

- *New Doctorate Graduates:* is a variable that refers to the presence of new research doctorates per 1000 inhabitants between the ages of 25 and 34 [26]. There is a negative relationship between the value of doctorates and the value of investment in industrial patents. This negative relationship can be understood considering that also the production of research doctorates is necessary for the development of industrial patents intended as an output of scientific research. However, increasing the number of graduate students does not in itself guarantee that there are industries capable of developing industrial patents. Take for example the case of Italy, where there are many PhD programs. Yet the number of industrial patents is reduced precisely due to the lack of companies operating in industrial sectors that require scientific research.

Average Values of Econometric Estimation of Patent Application	
Variables	**Average**
Human resources	0,44441
Intellectual assets	0,38039
Turnover share SMEs	0,29037
Knowledge-intensive services exports	0,15826
Private co-funding of public R&D expenditures	0,14700
R&D expenditure business sector	0,13349
Linkages	0,07981
Opportunity-driven entrepreneurship	-0,03195
Trademark applications	-0,13621
New doctorate graduates	-0,13656
Foreign-controlled enterprises share of value added	-0,14336
Tertiary education	-0,15606
Employment share Manufacturing	-0,40320
Total Entrepreneurial Activity	-0,47520

Table 2. Average Values of Econometric Estimation of Patent Application

- *Foreign-Controlled Enterprises Share of Value Added:* is a variable that considers the turnover achieved by companies that are under foreign control compared to the total turnover of companies operating at national level. There is a negative relationship between the value of the turnover achieved by companies with foreign control and the value of industrial patents. This negative relationship can be better understood considering that companies often allocate offices abroad to enter new markets or to have lower costs of raw materials, labor, or intermediate consumables. In other words, generally, even the companies that invest in research and development tend to keep the scientific research function close to the headquarters, or in the country of origin. This choice is generally of a strategic nature and consists in the need to ensure that industrial patents and technological innovation are better protected from competition and immediately known to management. R&D due to its function tends to be an asset that in high-tech companies is strictly controlled by industrial management near the decision-making centers.

- *Tertiary Education:* considers the percentage of the population aged between 25 and 34 who have completed tertiary education. There is a negative relationship between the value of the population having a tertiary qualification and the spread of industrial patents. This relationship can also be better understood in the light of what was stated in the previous point. In other words, a country that has a qualified human capital also in terms of tertiary education does not necessarily have the possibility of developing industrial patents. In fact, the possibility of realizing industrial patents depends above all on the presence of companies, manufacturers, large industrial groups that need to develop new patents. These are companies that are not very widespread in Europe, at least not in all countries, regardless of whether there is a population trained in terms of tertiary education.
- *Employment Share Manufacturing:* is the number of employees in the manufacturing sector as a percentage of the total number of employees. There is a negative relationship between the value of employees in the manufacturing sector and the value of industrial patents. This relationship is indeed counterfactual. In fact, in general the manufacturing sector, that is the industry, has a very high capacity to produce industrial patents. The lack of a positive relationship between industrial patents depends on the type of industries present in Europe. In particular, the European economies have lost their competitive capacity towards both the United States and towards Asian countries, especially with reference to China, Japan, and South Korea. It follows that even if in theory there should be a positive relationship between the value of manufacturing and the value of industrial patents, in the case of Europe this relationship is negative, due to the low added value in terms of knowledge of European industries.
- *Total Entrepreneurial Activity:* is a variable that considers the percentage of the population engaged in carrying out an entrepreneurial activity between the ages of 18 and 64. The variable includes both people who have created new businesses and long-time entrepreneurs. There is a negative relationship between the value of the Total Entrepreneurial Activity-TEA and the value of industrial patents. Again the relationship appears to be counterfactual. In fact, from the metric analysis it is possible to deduce that European entrepreneurs increase even where industrial patents decrease. However, this relationship can best be understood considering that in the European context, companies are not strictly connected to the systems of technological innovation and scientific research, apart from the exceptions for the most virtuous countries. This report suggests that the European business system is not really oriented towards the knowledge economy. In fact, the abundance of small and medium-sized enterprises, the scarce orientation towards products and technological innovation, and the lack of adequate fruitful relationships between enterprises and research institutions annihilates the ability of European enterprises to generate profit through industrial patents.

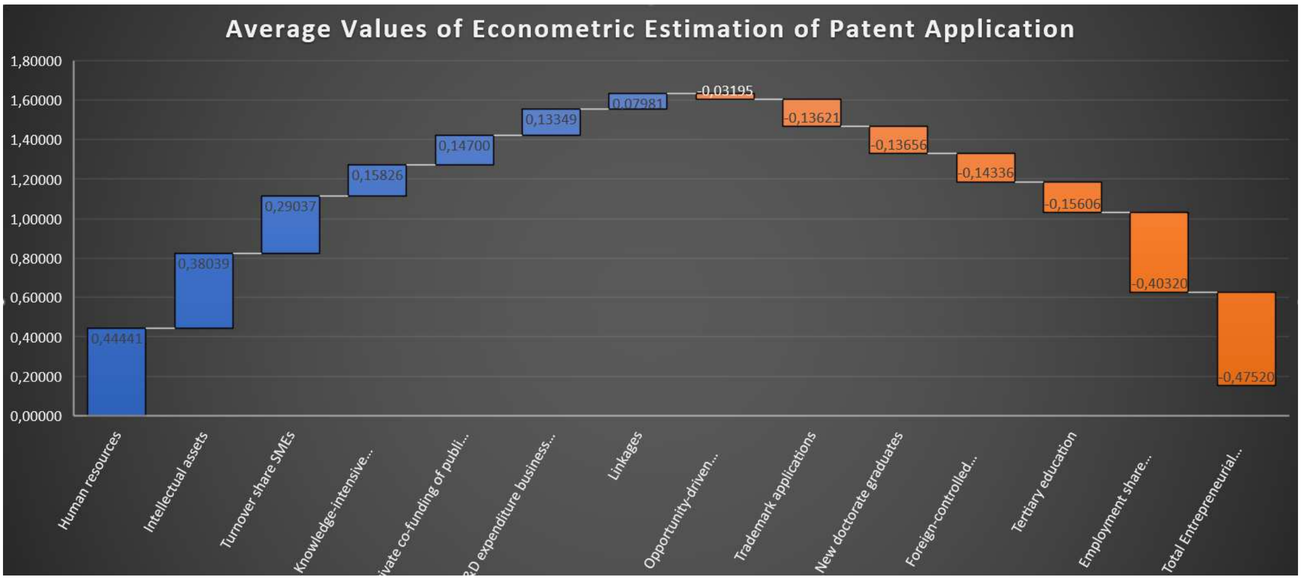

Figure 1. Average Values of Econometrics Estimation of Patent Application.

From a strictly quantitative point of view, it is possible to verify that the variables that have the greatest positive impact in terms of production of industrial patents are Human Resources with an average value of 0.44 and Intellectual Assets with an average value of 0.38. On the contrary, the variables that have the greatest negative impact in terms of industrial patenting are Employment Share of Manufacturing with a value equal to -0.40 and Total Entrepreneurial Activity-TEA with an amount equal to -0.47 units. It is necessary to consider that these relations cannot be considered in absolute value, but on the contrary in a relative sense, that is, they must be considered in the light of the specific characteristics of the European economy. In fact, if on the one hand the idea that Human Resources and Intellectual Assets have a positive impact in terms of industrial patent production is certainly acceptable, on the other hand the negative relationship that Employment Share of Manufacturing and Total Entrepreneurial Activity-TEA may seem counterfactual. However, the analysis shows that the European business sector, due to its qualitative and quantitative characteristics, is not really connected with the knowledge economy, synthesized by industrial patents. And this scarce impact of patents in the European business context highlights the gap that is emerging at an industrial level among Europe, the US and Asia.

4. Ranking of Countries and Clusterization with k-Means Algorithm Optimized with the Silhouette Coefficient

In the following analysis, we try to study the data to identify the presence of any groups, classifications and clusters that can somehow identify the presence of virtuous European economic areas in the sense of the production of patents.

Israel and Sweden are in first place by value of Patent Applications in 2021 with an amount equal to 225.24 units, followed by Finland with an amount equal to 221.19 units and by Switzerland with an amount equal to 192.42. In the middle of the table there are Estonia with an amount equal to 45.99 units, followed by Spain with an amount equal to 37.55 units and Malta with a value equal to 36.04 units. Bosnia closes the ranking with an amount equal to 2.84 and Serbia and Montenegro with a value equal to zero.

It is also possible to create a ranking based on the percentage change in the value of Patent Applications between 2016 and 2021. In this sense, Cyprus is in first place with a value of 84.67% equal to an amount of 7.09 units, followed by Malta with an amount equal to 72.43% equal to a value of 15.14 units, and by

Latvia with a value equal to 62.59% equal to an amount of 8.68 units. In the middle of the table there are Luxembourg with a value equal to -2.78% equal to an amount of -1.39 units, followed by Denmark with a value equal to -6.72% equal to an amount of -12.33. units, and from the Netherlands with a value equal to -6.99% equal to an amount of -10.52 units. Bosnia closes the ranking with a change equal to an amount of -51.07% equal to an amount of -2.96 units, followed by Montenegro with -100.00% equal to an amount of -17.58 units and by Serbia with an amount equal to -100.00% equal to a value of -8.79 units.
However, to check if there are particularly aggregate details within European countries, a clusterization with K-means algorithm optimized with the silhouette coefficient is carried out. The analysis shows the presence of the following clusters, namely:

- *Cluster 1*: Belgium, United Kingdom, Iceland, Norway, Slovenia, Ireland, Italy, Luxembourg, Spain, Estonia, Hungary, North Macedonia, Malta, Montenegro, Bosnia, Romania, Serbia, Latvia, Czech Republic, Ukraine, Cyprus, Lithuania, Portugal, Slovakia, Croatia, Bulgaria, Greece, Poland, Turkey;
- *Cluster 2*: Switzerland, Germany, Finland, Switzerland, Israel, Denmark, the Netherlands, Austria, France.

From the point of view of the median, the presence of a clear distinction between cluster 1 and cluster 2 is evident. In fact, the median of cluster 1 is equal to an amount of 20.8312 units while the median of cluster 2 is equal to a value of 181.009. Therefore, the following ordering of the clusters derives, i.e. C2> C1.

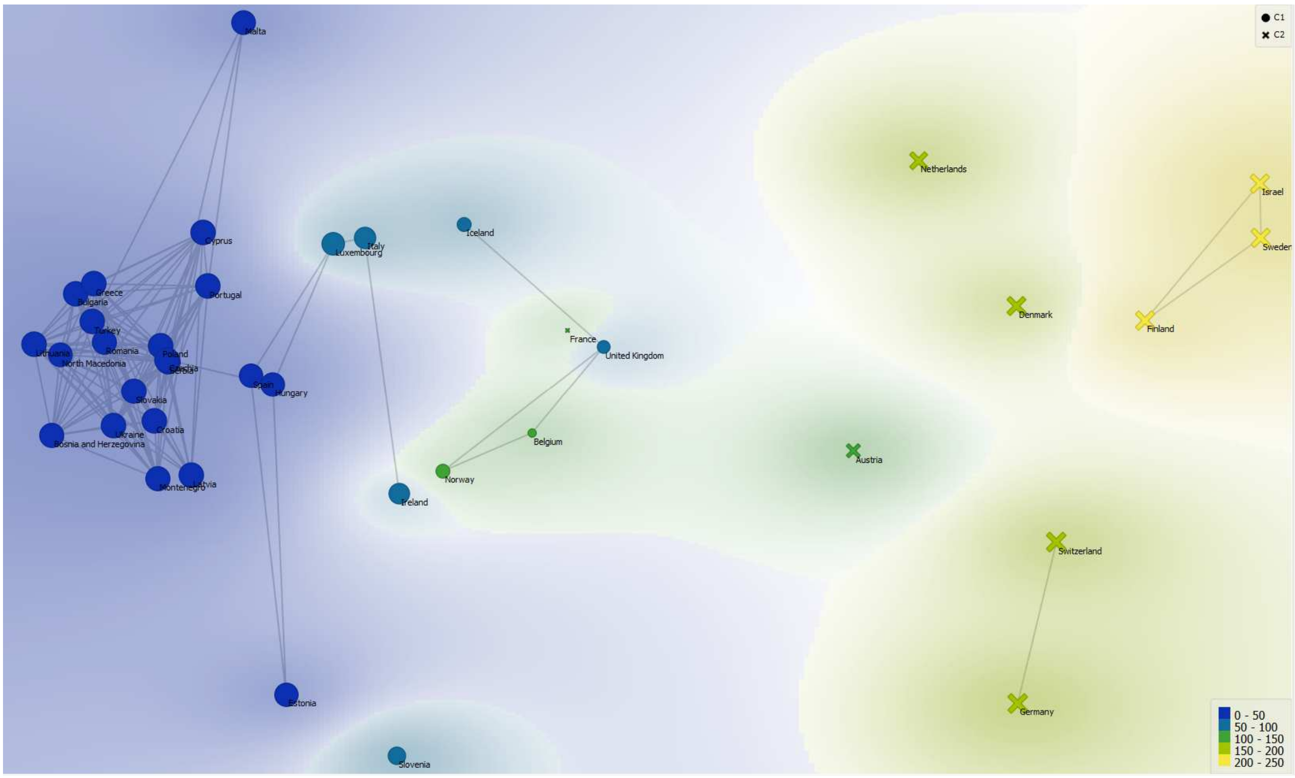

Figure 2. Clusterization with k-Means algorithm optimized with Silhouette Coefficient.

5. Network Analysis with the Distance of Manhattan

A network analysis using the Manhattan distance is analyzed below. The data show the presence of three complex network structures, that is, consisting of more than two connections. Particularly:

- Cyprus has a connection with Greece for a value of 0.098 units, and with Bulgaria for a value of 0.096 units;
- Greece has a connection with Cyprus for a value of 0.098 units, with Bulgaria for a value of 0.06 units, with Poland for a value of 0.068 units, and Slovakia for a value of 0.078 units , with Ukraine for a value of 0.093 units;
- Bulgaria has a connection with Greece for a value equal to 0.06 units, with Cyprus for a value equal to 0.096 units, with Ukraine for a value equal to 0.11 with Poland for a value equal to 0.067 unit;
- Ukraine has a connection with Bulgaria for a value of 0.11 units, with Slovakia for a value of 0.11 units, with Poland for a value of 0.11 units, with Greece for a value of 0.093 units;
- Slovakia has a connection with Ukraine for a value of 0.11 units, with Poland for a value of 0.094 units, with Turkey for a value of 0.11 units, with Greece for a value of equal to 0.078 units;
- Poland has a connection with Greece for a value equal to 0.068 units, with Bulgaria for a value equal to 0.067 units, with Ukraine for a value equal to 0.11 units, with Slovakia equal to an amount of 0.094 and with Turkey equal to 0.089 units;
- Turkey has a connection with Slovakia for a value of 0.11 units, with Greece for a value of 0.11 units, and with Poland for a value of 0.089 units.

There is also a connection between Sweden, Finland and Israel. Particularly:

- There is a connection between Sweden and Israel for an approximate value of 0, and between Sweden and Finland equal to an amount of 0.086 units;
- Finland has a connection with Sweden equal to 0.086 units and with Israel equal to 0.086 units;
- Israel has a connection with Finland for a value of 0.086 units and with Sweden for a value close to zero.

There is also a connection between Bosnia, Romania, and Serbia. Particularly

- Bosnia has a connection with Romania for a value of 0.087 units;
- Romania has a connection with Bosnia for a value of 0.087 units and with Serbia for a value of 0.11 units;
- Serbia has a connection with Romania for a value of 0.11 units.

6. Machine Learning and Predictions of the Future Value of Patent Application

Eight machine learning algorithms are applied below for predicting the future value of Patent Applications in Europe. The algorithms were trained with 70% of the data, while the remaining 30% was used for actual prediction. The algorithms have been classified based on their ability to maximize R-squared and minimize statistical errors, namely: "*Mean Absolute Error*", "*Mean Squared Error*", "*Root Mean Squared Error*". The following algorithm order was then obtained, namely:

- PNN-Probabilistic Neural Network with a payoff value of 7;
- Linear Regression and Polynomial Regression with a payoff value of 11;
- Tree Ensemble Regression with a payoff value of 15;
- Neural Network with a payoff value of 19;
- Random Forest Regression with a payoff value of 23;
- Gradient Boosted Tree with a payoff value of 27;
- Simple Regression with a value of 31.

Therefore, through the application of the PNN-Probabilistic Neural Network algorithm, it is possible to predict the following variations for the following countries in terms of Patent Applications, namely:

- Austria with a variation from an amount of 137.42 units up to a value of 150.25 units or equal to a variation of 12.84 units equal to an amount of 9.34%;

- Belgium with a variation from an amount of 88.63 units up to a value of 96.96 units or equal to an amount of 8.32 units equal to a value of 9.39%;
- Switzerland with a variation from an amount of 192.42 units up to a value of 193.10 units or equal to a variation of 0.67 units equal to a value of 0.35%;
- Denmark with a variation from an amount of 171.10 units up to a value of 182.58 units or equal to a value of 11.48 units equal to a value of 6.71%;
- Spain with a variation from an amount of 37.55 units up to a value of 35.97 units or equal to an amount of -1.57 units equal to a value of -4.19%;
- Ireland with a variation from an amount of 49.35 units up to a value of 52.73 units or equal to an amount of 3.38 units or equal to a value of 6.85%;
- Italy with a variation from an amount of 59.10 units up to a value of 48.04 units or equal to a value of -11.05 units equal to a value of -18.7%;
- Latvia with a variation from an amount of 22.54 units up to a value of 20.51 units or equal to a value of -2.03 units equal to an amount of -9%;
- Norway with a variation from an amount of 87.92 units up to a value of 85.44 units or equal to a value of -2.48 units equal to a value of -2.82%;
- United Kingdom with a variation from an amount of 84.13 units up to a value of 85.03 units or equal to an amount of 0.90 units equal to a value of 1.07%.

7. Conclusions

In this article we have investigated the innovational determinants of "*Patent Applications*" in Europe. The issue is particularly relevant above all for the issue connected to the tech-war between China and the USA which has a very important aspect in the recognition of patents, especially with reference to the various violations that the Chinese often put in place against technological innovations from the West. . Although it should be emphasized that the Chinese themselves, as indicated in the literature, have begun to be very attentive to the quality of the production of patents using international standards and metrics. We have used data from the European Innovation Scoreboard-EIS of the European Commission for 36 countries in the period 2010-2019. We have applied Panel Data with Fixed Effects, Panel Data with Random Effects, Pooled OLS, WLS and Dynamic Panel. We found that the variables that have a deeper positive association with "*Patent Applications*" are "*Human Resources*" and "*Intellectual Assets*", while the variables that show a more intense negative relation with Patent Applications are "*Employment Share in Manufacturing*" and "*Total Entrepreneurial Activity*". The econometric results interpreted from a qualitative point of view highlight the backwardness of the European business system in using patents. European companies are probably too small to be able to introduce patents and, moreover, even the development of human capital, however necessary it is, may be insufficient to create the conditions for patents due to the lack of proposing companies. The result is a type of entrepreneurship that, rather than producing new knowledge through patents, tends to seize the opportunities present in the market with little capacity for innovation.
In the following section a cluster analysis with the k-Means algorithm optimized with the Silhouette Coefficient has been realized. The results show the presence of two clusters. The most active countries in the sense of patents are: Switzerland, Germany, Finland, Switzerland, Israel, Denmark, the Netherlands, Austria, France. These nations are also the richest in per capita terms, which seems to confirm what is reported in the scientific literature that the regions with the highest per capita incomes also tend to produce more patents. In the sequent paragraph a network analysis with the distance of Manhattan has been performed and we find three different complex network structures. Finally, a comparison is made among eight machine learning algorithms for the prediction of the future value of

the "*Patent Applications*". We found that PNN-Probabilistic Neural Network is the best performing algorithm. Using PNN the results show that the mean future value of "*Patent Applications*" in the estimated countries is expected to decrease of -0.1%. Overall, the analysis shows how the European business system, except for the countries with the highest per capita income, is not actually capable of generating high levels of technological innovation recognized as patents. This condition is particularly serious for Europe, which is struggling in the global technological competition overcome not only by the USA but also by China and other Asian countries such as Japan and South Korea. Hence the need to reorganize the economic policies of technological innovation and scientific knowledge in Europe to promote incentives to offer to companies that want to increase the production of patents also in connection with public and private research centers.

8. Declarations

Data Availability Statement. The data presented in this study are available on request from the corresponding author.
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Declaration of Competing Interest. The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication.
Software. The authors have used the following software: Gretl for the econometric models, Orange for clusterization and network analysis, and KNIME for machine learning and predictions. They are all free version without licenses.
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10. Appendix

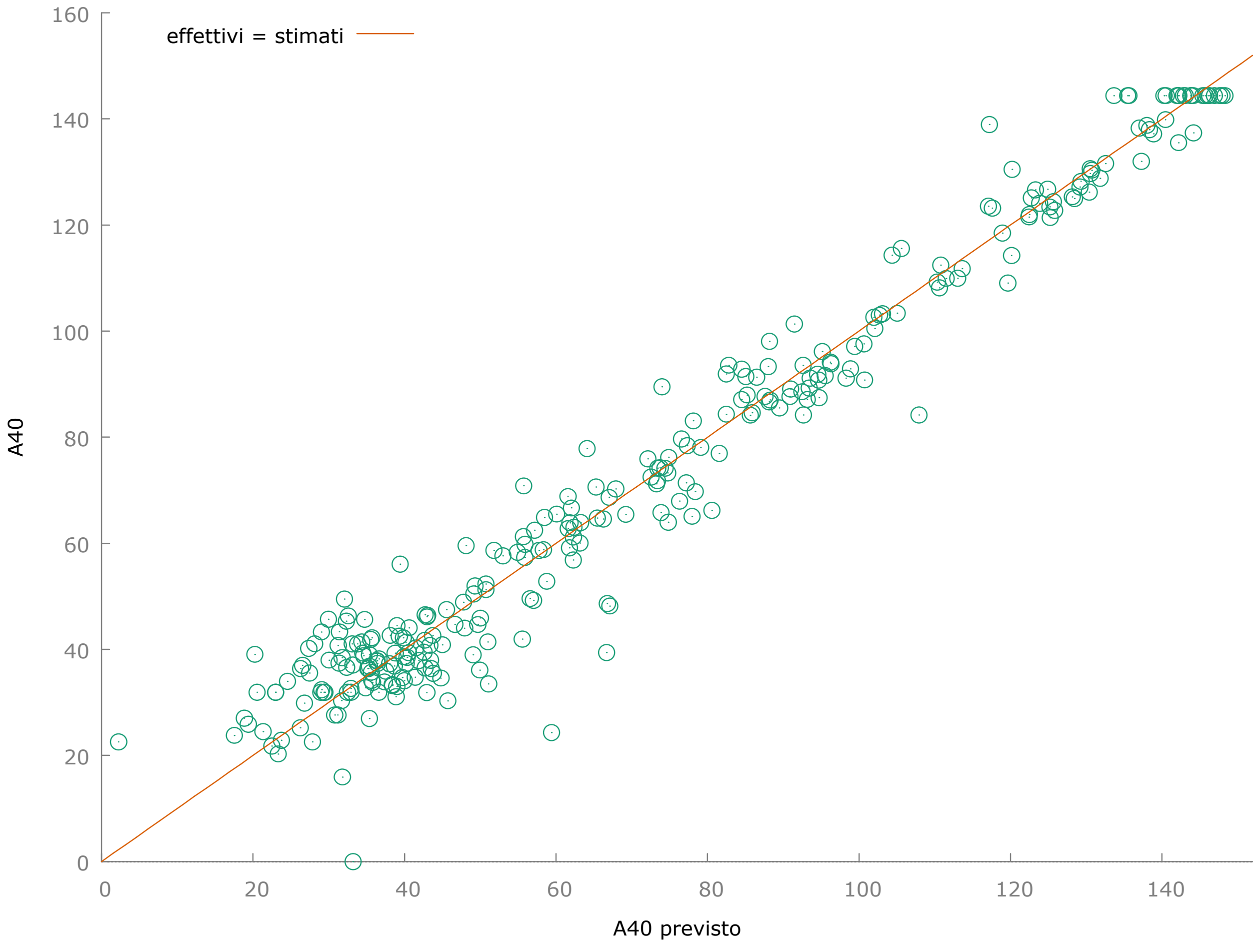
Modello 53: Panel dinamico a un passo, usando 288 osservazioni
Incluse 36 unità cross section
Matrice H conforme ad Ox/DPD
Variabile dipendente: A40

	Coefficiente	*Errore Std.*	*z*	*p-value*	
A40(-1)	0,0195703	0,0222747	0,8786	0,3796	
const	−0,167732	0,318341	−0,5269	0,5983	
A12	−0,309482	0,0767453	−4,033	<0,0001	***
A20	−0,220997	0,0953241	−2,318	0,0204	**

A23	0,437229	0,105651	4,138	<0,0001	***
A29	0,356362	0,110165	3,235	0,0012	***
A31	0,133296	0,0507438	2,627	0,0086	***
A33	0,114188	0,0555318	2,056	0,0398	**
A37	−0,131717	0,0485667	−2,712	0,0067	***
A39	−0,0371926	0,0187718	−1,981	0,0476	**
A43	0,112665	0,0373895	3,013	0,0026	***
A46	0,143547	0,0595938	2,409	0,0160	**
A53	−0,147486	0,0320065	−4,608	<0,0001	***
A55	−0,566507	0,136132	−4,161	<0,0001	***
A56	−0,118842	0,0582662	−2,040	0,0414	**
A58	0,286839	0,0595146	4,820	<0,0001	***

Somma quadr. residui	15851,36	E.S. della regressione	7,633941

Numero di strumenti = 36
Test per errori AR(1): z = -2,45312 [0,0142]
Test per errori AR(2): z = -1,43702 [0,1507]
Test di sovra-identificazione di Sargan: Chi-quadro(20) = 22,0211 [0,3394]
Test (congiunto) di Wald: Chi-quadro(15) = 3062,24 [0,0000]

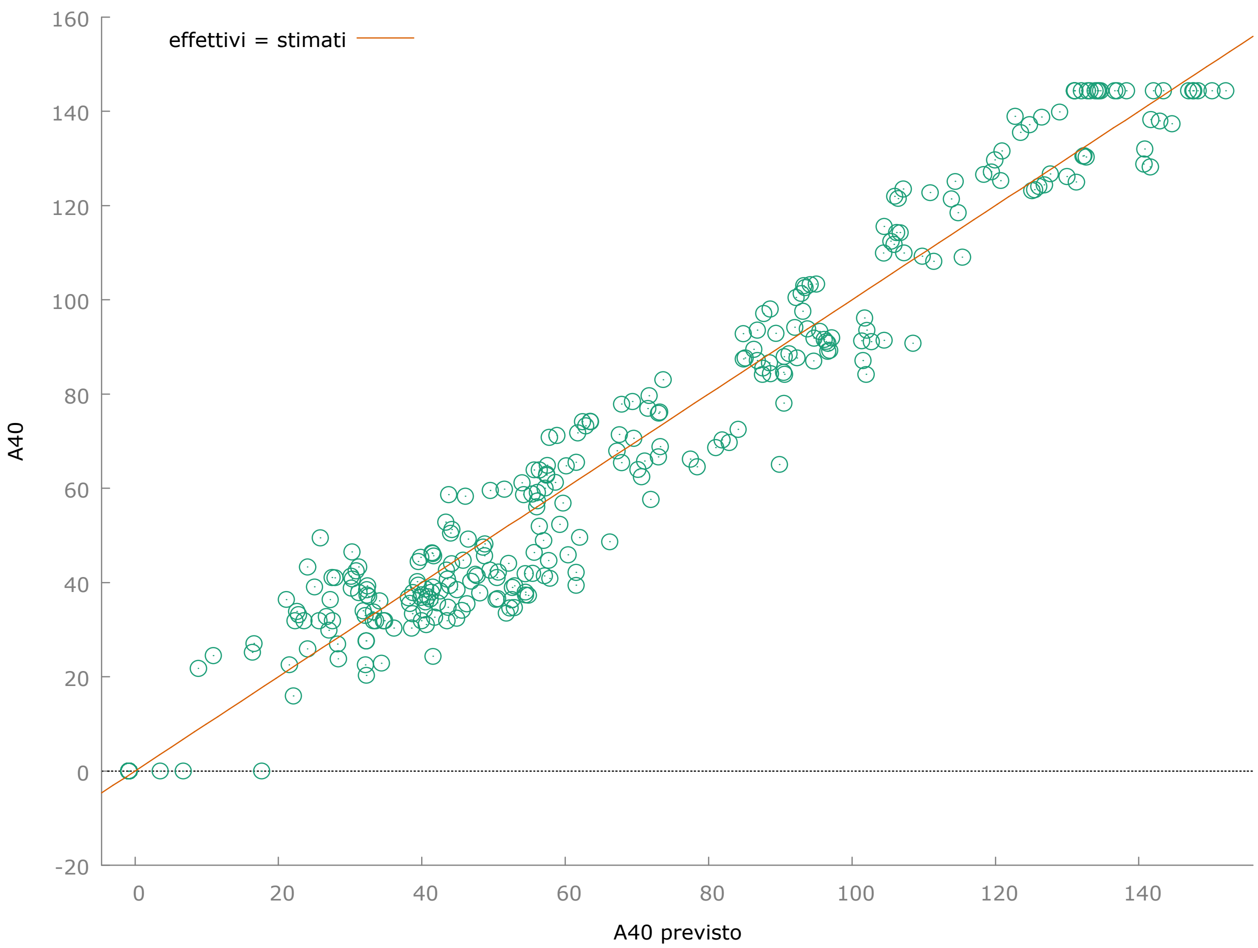


Modello 54: Pooled OLS, usando 360 osservazioni
Incluse 36 unità cross section
Lunghezza serie storiche = 10
Variabile dipendente: A40

	Coefficiente	*Errore Std.*	*rapporto t*	*p-value*	
const	−0,851697	0,854705	−0,9965	0,3197	
A12	−0,514046	0,0433517	−11,86	<0,0001	***
A20	−0,153258	0,0344100	−4,454	<0,0001	***
A23	0,440667	0,0280782	15,69	<0,0001	***
A29	0,413132	0,0251882	16,40	<0,0001	***
A31	0,159265	0,0168682	9,442	<0,0001	***
A33	0,0778794	0,0280777	2,774	0,0058	***
A37	−0,129864	0,0160699	−8,081	<0,0001	***
A39	−0,0467895	0,0107081	−4,370	<0,0001	***

A43	0,165174	0,0198724	8,312	<0,0001	***
A46	0,134517	0,0132746	10,13	<0,0001	***
A53	−0,153121	0,0133004	−11,51	<0,0001	***
A55	−0,417076	0,113620	−3,671	0,0003	***
A56	−0,157970	0,0154754	−10,21	<0,0001	***
A58	0,348121	0,0406096	8,572	<0,0001	***

Media var. dipendente	57,46422	SQM var. dipendente	44,67394
Somma quadr. residui	24665,96	E.S. della regressione	8,455504
R-quadro	0,965573	R-quadro corretto	0,964176
F(14, 345)	691,1641	P-value(F)	1,4e-242
Log-verosimiglianza	−1271,691	Criterio di Akaike	2573,383
Criterio di Schwarz	2631,674	Hannan-Quinn	2596,561
rho	0,689770	Durbin-Watson	0,659715



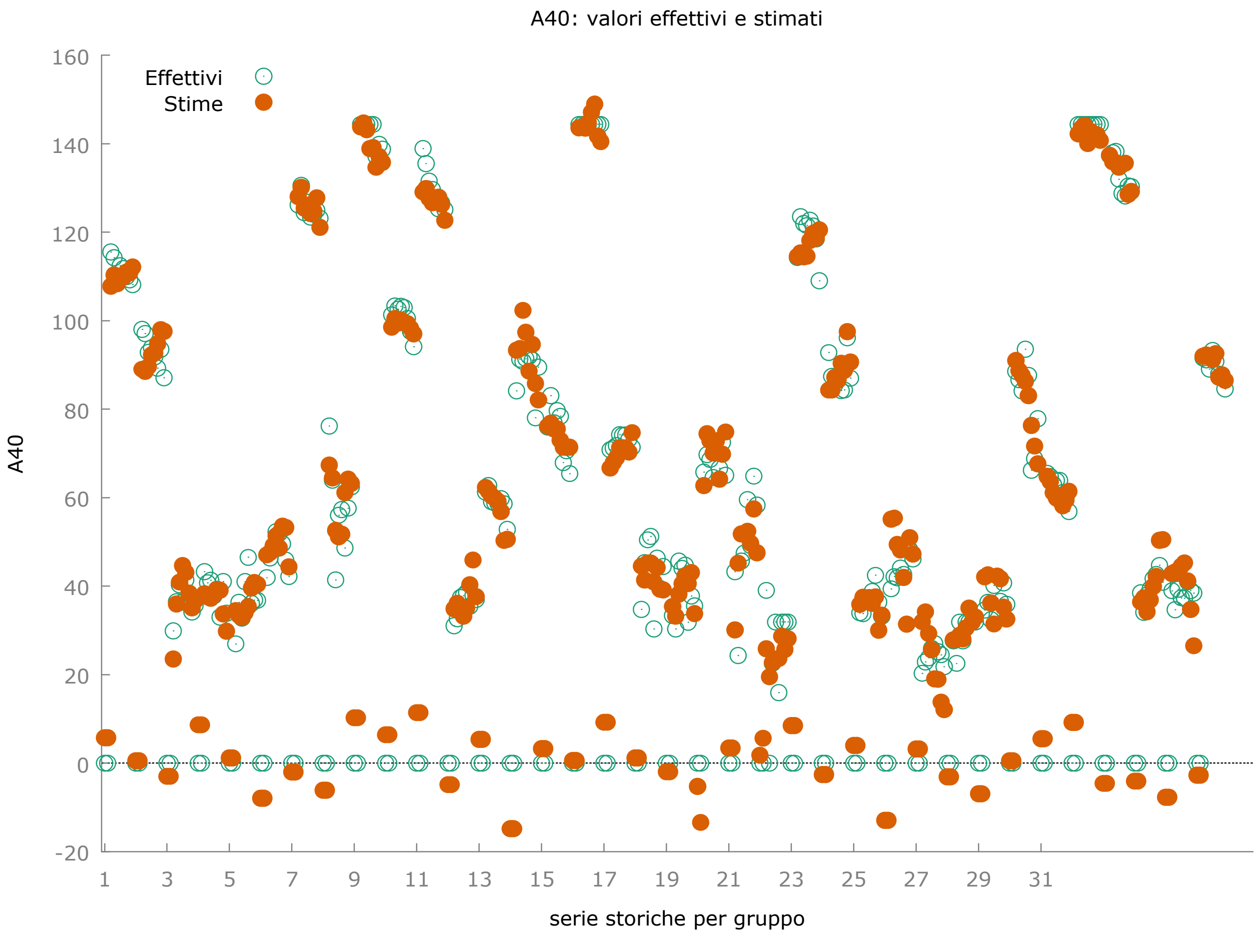
Modello 55: Effetti fissi, usando 360 osservazioni
Incluse 36 unità cross section
Lunghezza serie storiche = 10
Variabile dipendente: A40

	Coefficiente	*Errore Std.*	*rapporto t*	*p-value*	
const	0,0387197	0,692629	0,05590	0,9555	
A12	−0,324907	0,0540015	−6,017	<0,0001	***
A20	−0,115415	0,0483767	−2,386	0,0176	**
A23	0,427791	0,0419228	10,20	<0,0001	***
A29	0,351286	0,0312121	11,25	<0,0001	***
A31	0,166165	0,0248301	6,692	<0,0001	***
A33	0,0685645	0,0326572	2,100	0,0366	**
A37	−0,133389	0,0223540	−5,967	<0,0001	***
A39	−0,0224884	0,0117898	−1,907	0,0574	*
A43	0,143533	0,0254919	5,631	<0,0001	***
A46	0,144807	0,0169123	8,562	<0,0001	***
A53	−0,147862	0,0180874	−8,175	<0,0001	***
A55	−0,439047	0,128428	−3,419	0,0007	***
A56	−0,124353	0,0193903	−6,413	<0,0001	***
A58	0,226421	0,0381361	5,937	<0,0001	***

Media var. dipendente	57,46422	SQM var. dipendente	44,67394
Somma quadr. residui	11768,83	E.S. della regressione	6,161490
R-quadro LSDV	0,983574	R-quadro intra-gruppi	0,969555
LSDV F(49, 310)	378,8283	P-value(F)	2,4e-248
Log-verosimiglianza	−1138,497	Criterio di Akaike	2376,994
Criterio di Schwarz	2571,299	Hannan-Quinn	2454,253
rho	0,236676	Durbin-Watson	1,348078

Test congiunto sui regressori -
Statistica test: F(14, 310) = 705,156
con p-value = P(F(14, 310) > 705,156) = 1,61584e-225

Test per la differenza delle intercette di gruppo -
Ipotesi nulla: i gruppi hanno un'intercetta comune
Statistica test: F(35, 310) = 9,7063
con p-value = P(F(35, 310) > 9,7063) = 1,52768e-032



Modello 56: Effetti casuali (GLS), usando 360 osservazioni
Incluse 36 unità cross section
Lunghezza serie storiche = 10
Variabile dipendente: A40

	Coefficiente	*Errore Std.*	*z*	*p-value*	
const	−0,0646061	1,19690	−0,05398	0,9570	
A12	−0,367754	0,0496663	−7,404	<0,0001	***
A20	−0,123468	0,0430227	−2,870	0,0041	***
A23	0,431689	0,0366470	11,78	<0,0001	***
A29	0,365005	0,0286706	12,73	<0,0001	***
A31	0,161329	0,0217691	7,411	<0,0001	***
A33	0,0726235	0,0304959	2,381	0,0172	**
A37	−0,132162	0,0199159	−6,636	<0,0001	***
A39	−0,0272749	0,0111510	−2,446	0,0144	**
A43	0,149989	0,0231531	6,478	<0,0001	***
A46	0,140551	0,0153721	9,143	<0,0001	***

A53	−0,150431	0,0161471	−9,316	<0,0001	***
A55	−0,423613	0,120440	−3,517	0,0004	***
A56	−0,132408	0,0177444	−7,462	<0,0001	***
A58	0,249469	0,0367084	6,796	<0,0001	***

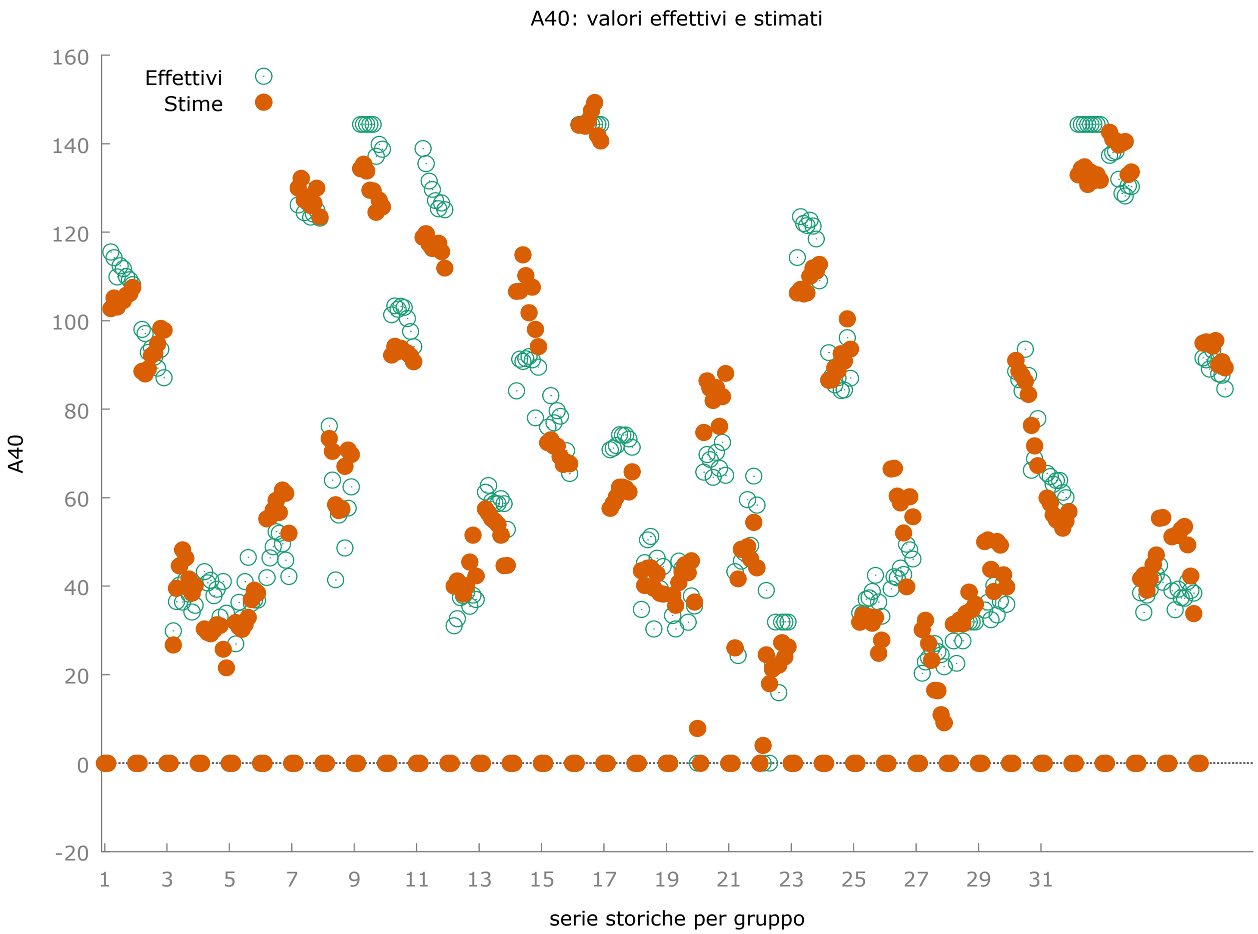
Media var. dipendente	57,46422	SQM var. dipendente	44,67394
Somma quadr. residui	26521,99	E.S. della regressione	8,755179
Log-verosimiglianza	−1284,750	Criterio di Akaike	2599,501
Criterio di Schwarz	2657,793	Hannan-Quinn	2622,679
rho	0,236676	Durbin-Watson	1,348078

Varianza 'between' = 33,9241
Varianza 'within' = 37,964
Theta usato per la trasformazione = 0,682753

Test congiunto sui regressori -
Statistica test asintotica: Chi-quadro(14) = 10531,7
con p-value = 0

Test Breusch-Pagan -
Ipotesi nulla: varianza dell'errore specifico all'unità = 0
Statistica test asintotica: Chi-quadro(1) = 280,209
con p-value = 6,76073e-063

Test di Hausman -
Ipotesi nulla: le stime GLS sono consistenti
Statistica test asintotica: Chi-quadro(14) = 21,4402
con p-value = 0,0908723



Modello 57: WLS corrette per l'eteroschedasticità, usando 360 osservazioni
Variabile dipendente: A40

	Coefficiente	*Errore Std.*	*rapporto t*	*p-value*	
const	−0,122259	0,183189	−0,6674	0,5050	
A12	−0,499800	0,0342980	−14,57	<0,0001	***
A20	−0,103651	0,0329219	−3,148	0,0018	***
A23	0,484696	0,0231161	20,97	<0,0001	***
A29	0,416170	0,0261246	15,93	<0,0001	***
A31	0,171232	0,0132462	12,93	<0,0001	***
A33	0,0657994	0,0204818	3,213	0,0014	***
A37	−0,155676	0,0133771	−11,64	<0,0001	***
A39	−0,0259872	0,00950615	−2,734	0,0066	***
A43	0,163626	0,0156434	10,46	<0,0001	***

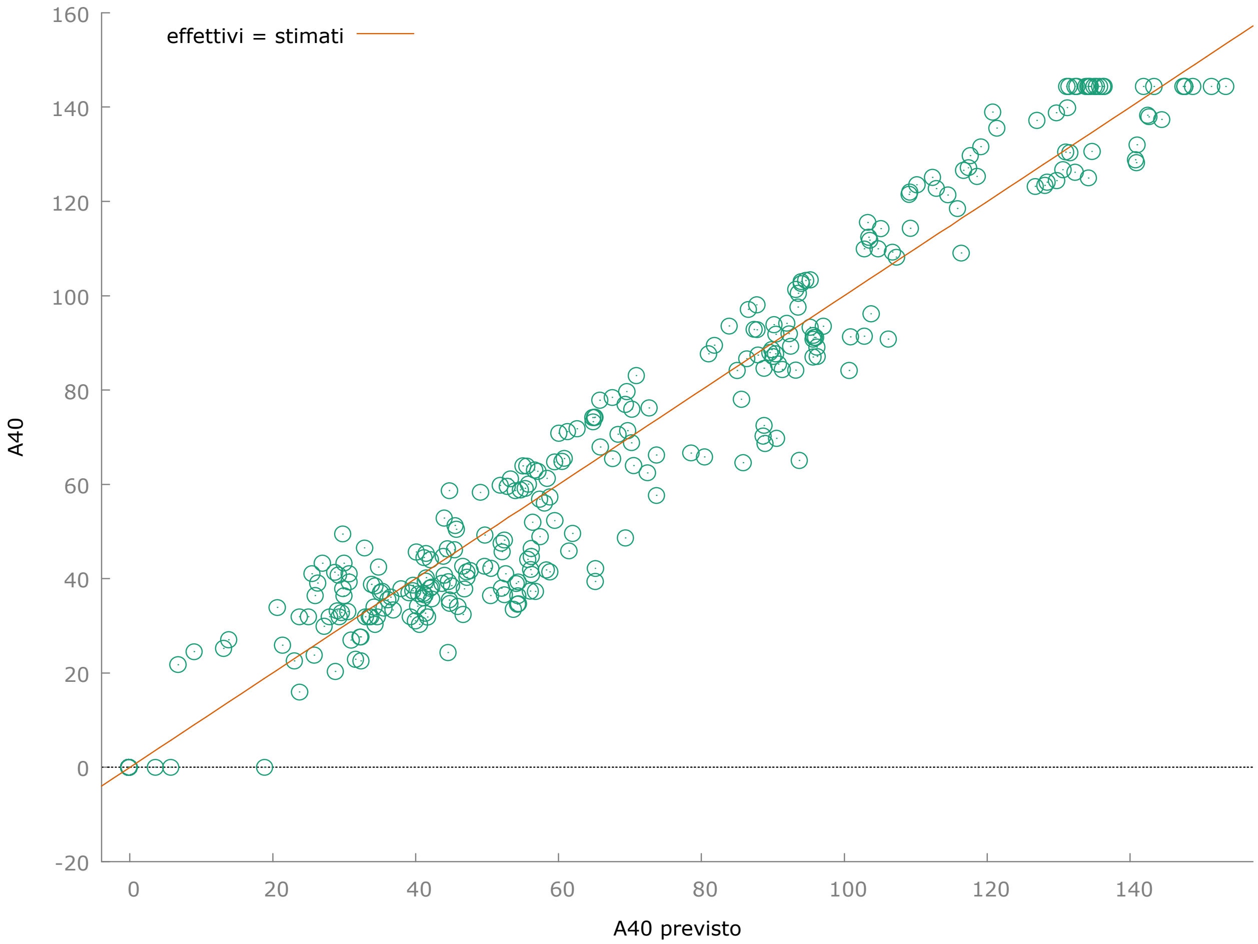
A46	0,104035	0,0112198	9,272	<0,0001	***
A53	−0,181417	0,0109124	−16,62	<0,0001	***
A55	−0,529756	0,122247	−4,333	<0,0001	***
A56	−0,147489	0,0153023	−9,638	<0,0001	***
A58	0,341017	0,0352566	9,672	<0,0001	***

Statistiche basate sui dati ponderati:

Somma quadr. residui	865,7964	E.S. della regressione	1,584157
R-quadro	0,987309	R-quadro corretto	0,986794
F(14, 345)	1917,084	P-value(F)	0,000000
Log-verosimiglianza	−668,7761	Criterio di Akaike	1367,552
Criterio di Schwarz	1425,844	Hannan-Quinn	1390,730

Statistiche basate sui dati originali:

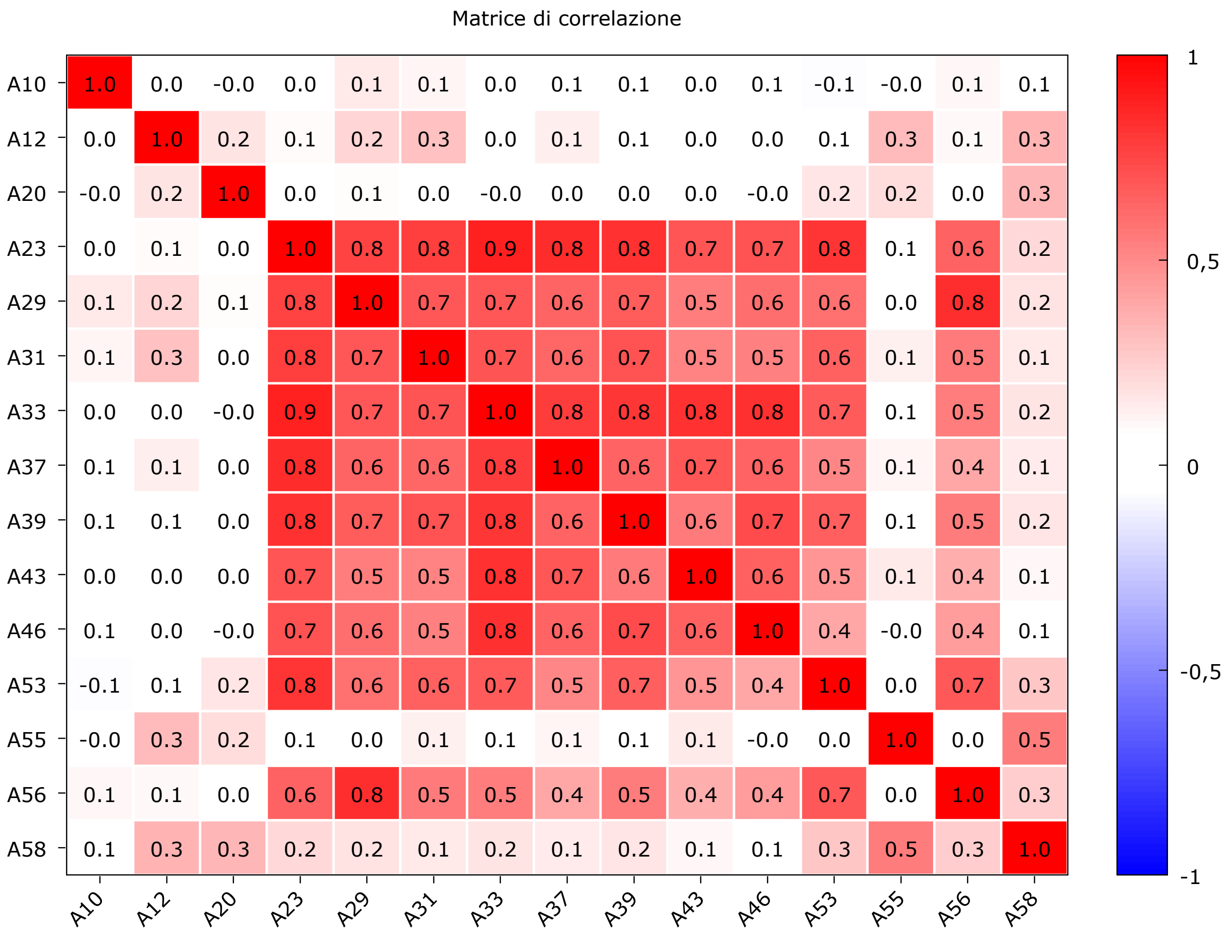
Media var. dipendente	57,46422	SQM var. dipendente	44,67394
Somma quadr. residui	26369,44	E.S. della regressione	8,742606



Statistiche descrittive, usando le osservazioni 1:01 - 36:10

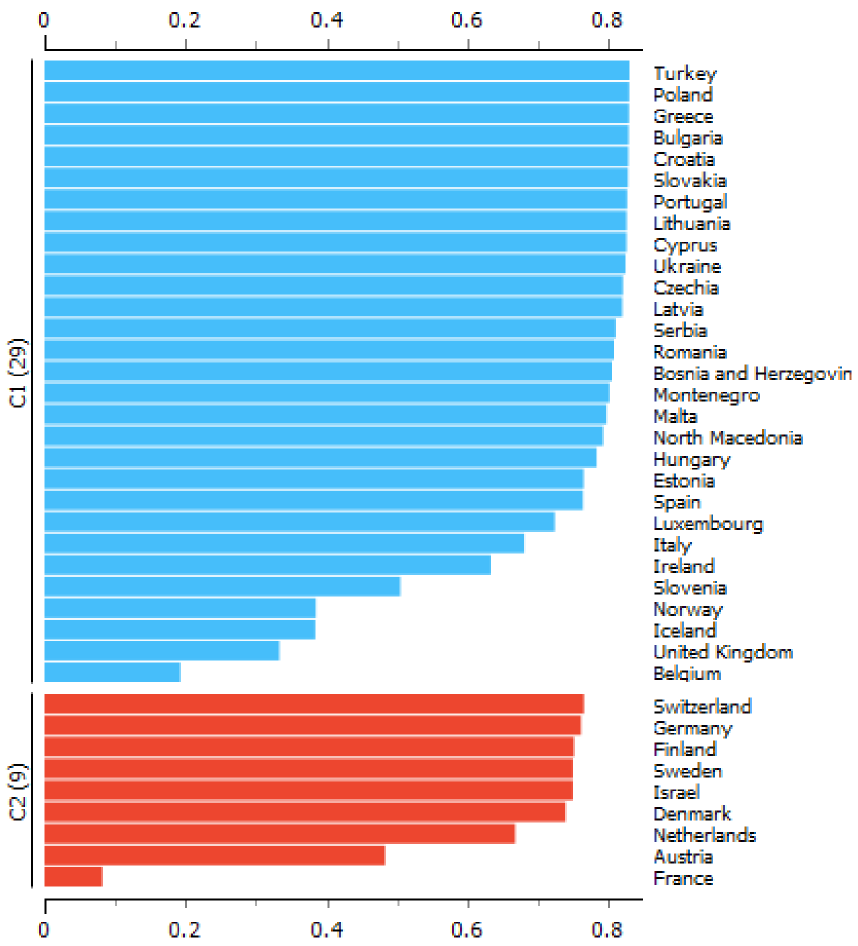
Variabile	Media	Mediana	Minimo	Massimo
A10	135,72	87,012	0,00000	2019,0
A12	4,4794	0,00000	0,00000	117,01
A20	5,2816	0,00000	0,00000	95,842
A23	90,897	84,007	0,00000	252,86
A29	65,865	70,699	0,00000	156,33
A31	60,206	55,536	0,00000	192,21
A33	78,414	70,374	0,00000	188,19
A37	75,186	63,374	0,00000	249,48
A39	85,070	67,137	0,00000	275,59
A43	59,223	64,148	0,00000	153,65
A46	67,460	43,741	0,00000	367,29
A53	100,28	85,537	0,00000	274,38
A55	1,9529	0,00000	0,00000	30,670
A56	80,535	75,740	0,00000	250,46
A58	6,4516	0,00000	0,00000	54,230

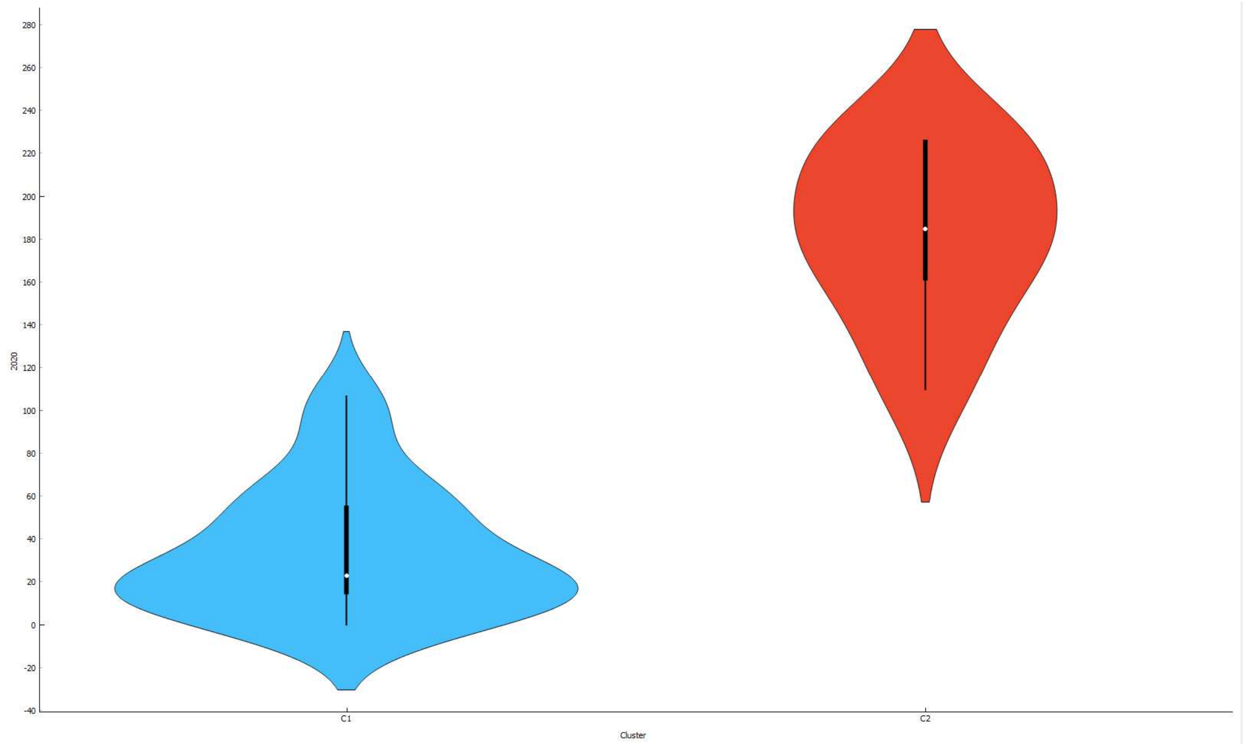
Variabile	SQM	Coeff. di variazione	Asimmetria	Curtosi
A10	322,91	2,3793	5,4749	29,021
A12	12,883	2,8761	5,3358	35,741
A20	15,323	2,9011	3,8776	15,680
A23	68,080	0,74898	0,26828	-0,91544
A29	48,645	0,73855	0,067354	-1,1580
A31	48,403	0,80395	0,29595	-1,0101
A33	58,614	0,74749	0,20037	-1,2255
A37	65,650	0,87316	0,62306	-0,47785
A39	86,220	1,0135	0,88117	-0,28263
A43	44,540	0,75207	0,21356	-0,81340
A46	72,489	1,0745	1,4581	2,3635
A53	86,011	0,85767	0,24590	-1,2552
A55	5,0350	2,5783	3,2325	11,595
A56	71,472	0,88747	0,77061	0,035233
A58	15,399	2,3869	2,0294	2,2966
Variabile	5% Perc.	95% Perc.	Range interquartile	Osservazioni mancanti
A10	0,00000	193,59	85,714	0
A12	0,00000	20,193	0,00000	0
A20	0,00000	37,863	0,00000	0
A23	0,00000	217,47	105,44	0
A29	0,00000	145,41	82,152	0
A31	0,00000	146,72	96,837	0
A33	0,00000	170,17	105,20	0
A37	0,00000	200,30	109,46	0
A39	0,00000	275,59	130,58	0
A43	0,00000	136,65	70,484	0
A46	0,00000	191,43	100,17	0
A53	0,00000	255,37	170,66	0
A55	0,00000	12,216	0,00000	0
A56	0,00000	250,46	114,76	0
A58	0,00000	45,894	0,00000	0

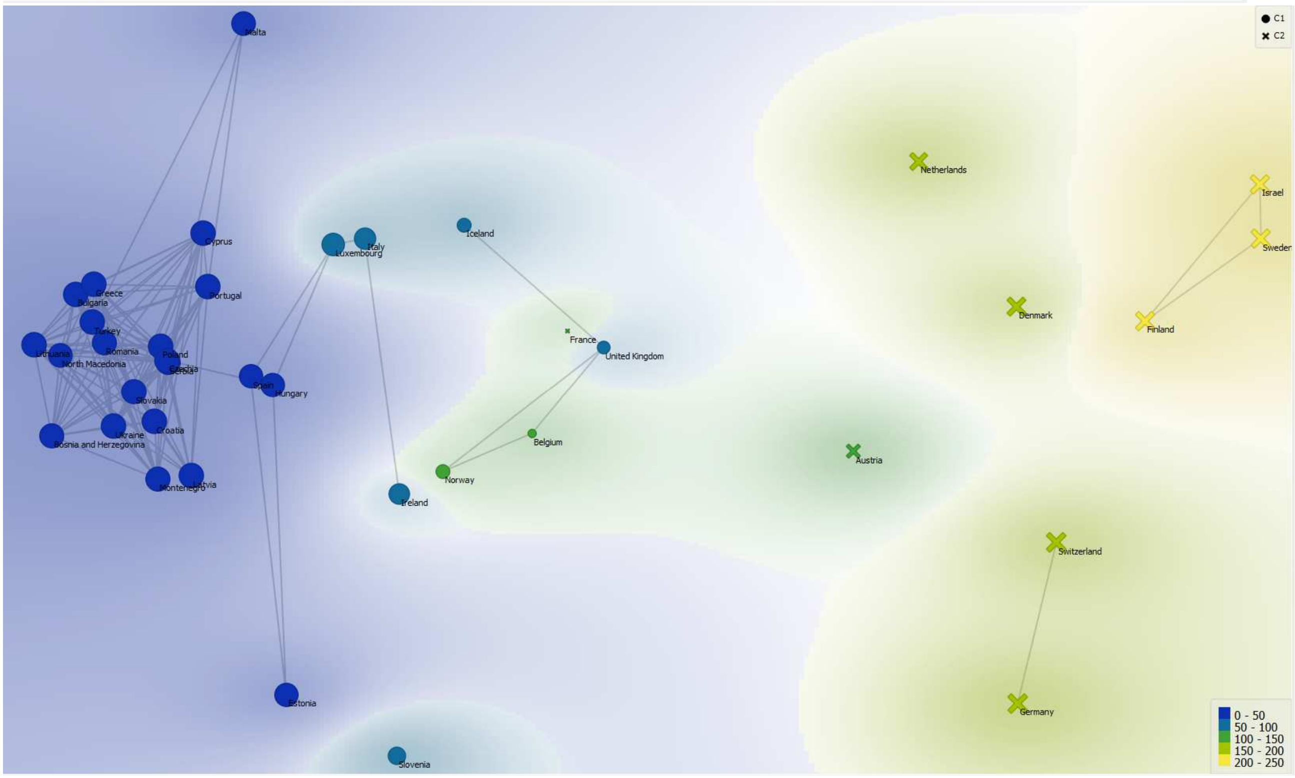

Matrice di correlazione
A10 1.0 0.0 -0.0 0.0 0.1 0.1 0.0 0.1 0.1 0.0 0.1 -0.1 -0.0 0.1 0.1
A12 0.0 1.0 0.2 0.1 0.2 0.3 0.0 0.1 0.1 0.0 0.0 0.1 0.3 0.1 0.3
A20 -0.0 0.2 1.0 0.0 0.1 0.0 -0.0 0.0 0.0 0.0 -0.0 0.2 0.2 0.0 0.3
A23 0.0 0.1 0.0 1.0 0.8 0.8 0.9 0.8 0.8 0.7 0.7 0.8 0.1 0.6 0.2
A29 0.1 0.2 0.1 0.8 1.0 0.7 0.7 0.6 0.7 0.5 0.6 0.6 0.0 0.8 0.2
A31 0.1 0.3 0.0 0.8 0.7 1.0 0.7 0.6 0.7 0.5 0.5 0.6 0.1 0.5 0.1
A33 0.0 0.0 -0.0 0.9 0.7 0.7 1.0 0.8 0.8 0.8 0.8 0.7 0.1 0.5 0.2
A37 0.1 0.1 0.0 0.8 0.6 0.6 0.8 1.0 0.6 0.7 0.6 0.5 0.1 0.4 0.1
A39 0.1 0.1 0.0 0.8 0.7 0.7 0.8 0.6 1.0 0.6 0.7 0.7 0.1 0.5 0.2
A43 0.0 0.0 0.0 0.7 0.5 0.5 0.8 0.7 0.6 1.0 0.6 0.5 0.1 0.4 0.1
A46 0.1 0.0 -0.0 0.7 0.6 0.5 0.8 0.6 0.7 0.6 1.0 0.4 -0.0 0.4 0.1
A53 -0.1 0.1 0.2 0.8 0.6 0.6 0.7 0.5 0.7 0.5 0.4 1.0 0.0 0.7 0.3
A55 -0.0 0.3 0.2 0.1 0.0 0.1 0.1 0.1 0.1 0.1 -0.0 0.0 1.0 0.0 0.5
A56 0.1 0.1 0.0 0.6 0.8 0.5 0.5 0.4 0.5 0.4 0.4 0.7 0.0 1.0 0.3
A58 0.1 0.3 0.3 0.2 0.2 0.1 0.2 0.1 0.2 0.1 0.1 0.3 0.5 0.3 1.0
A10 A12 A20 A23 A29 A31 A33 A37 A39 A43 A46 A53 A55 A56 A58
1
0,5
0
-0,5
-1

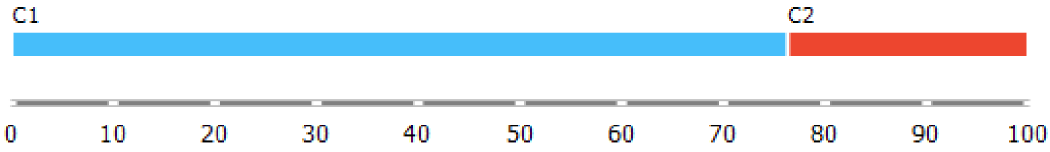
Ranking of European Countries for Patent Applications					
Rank	**Country**	**2021**	**Rank**	**Country**	**2021**
1	*Israel*	225,24	19	*Malta*	36,04
1	*Sweden*	225,24	20	*Hungary*	32,41
2	*Finland*	221,19	21	*Portugal*	24,94
3	*Switzerland*	192,42	22	*Latvia*	22,54
4	*Germany*	181,01	23	*Czechia*	20,83
5	*Denmark*	171,10	24	*Turkey*	19,90
6	*Netherlands*	139,96	25	*Greece*	16,49
7	*Austria*	137,42	26	*Slovakia*	15,65
8	*France*	103,80	27	*Cyprus*	15,47
9	*Iceland*	96,07	28	*Lithuania*	14,89
10	*Belgium*	88,63	29	*Bulgaria*	14,81
11	*Norway*	87,92	30	*Poland*	13,13
12	*United Kingdom*	84,13	31	*Croatia*	13,02
13	*Slovenia*	70,13	32	*Ukraine*	11,16
14	*Italy*	59,10	33	*North Macedonia*	7,71
15	*Ireland*	49,35	34	*Romania*	5,47
16	*Luxembourg*	48,48	35	*Bosnia and Herzegovina*	2,84
17	*Estonia*	45,59	36	*Montenegro*	0,00
18	*Spain*	37,55	36	*Serbia*	0,00

Ranking of countries by percentage change in the value of Patent Applications between 2016 and 2021							
Rank	**Countries**	**Var Ass**	**Var Per**	**Rank**	**Countries**	**Var Ass**	**Var Per**
1	*Cyprus*	7,09	84,67	20	*Netherlands*	-10,52	-6,99
2	*Malta*	15,14	72,43	21	*Switzerland*	-17,85	-8,49
3	*Latvia*	8,68	62,59	22	*Austria*	-16,41	-10,67
4	*Greece*	5,28	47,08	23	*Norway*	-11,29	-11,38
5	*Bulgaria*	4,53	44,03	24	*France*	-14,58	-12,31
6	*Portugal*	7,05	39,44	25	*United Kingdom*	-12,29	-12,75
7	*Iceland*	14,86	18,30	26	*Germany*	-41,36	-18,60
8	*Turkey*	2,95	17,40	27	*Belgium*	-22,12	-19,97
9	*Lithuania*	2,10	16,38	28	*Ukraine*	-2,96	-20,96
10	*Romania*	0,72	15,22	29	*Slovenia*	-20,22	-22,38
11	*Slovakia*	1,87	13,60	30	*Spain*	-11,89	-24,05
12	*Czechia*	0,72	3,60	31	*Hungary*	-10,57	-24,60
13	*Italy*	1,29	2,23	32	*Ireland*	-17,10	-25,73
14	*Israel*	0,00	0,00	33	*Estonia*	-22,61	-33,15
15	*Sweden*	0,00	0,00	34	*Croatia*	-8,53	-39,59
16	*Poland*	-0,17	-1,25	35	*Bosnia and Herzegovina*	-2,96	-51,07
17	*Finland*	-4,05	-1,80	36	*Montenegro*	-17,58	-100,00
18	*Luxembourg*	-1,39	-2,78	37	*Serbia*	-8,79	-100,00
19	*Denmark*	-12,33	-6,72				


0
0.2
0.4
0.6
0.8
C1 (29)
Turkey
Poland
Greece
Bulgaria
Croatia
Slovakia
Portugal
Lithuania
Cyprus
Ukraine
Czechia
Latvia
Serbia
Romania
Bosnia and Herzegovin
Montenegro
Malta
North Macedonia
Hungary
Estonia
Spain
Luxembourg
Italy
Ireland
Slovenia
Norway
Iceland
United Kingdom
Belgium
C2 (9)
Switzerland
Germany
Finland
Sweden
Israel
Denmark
Netherlands
Austria
France


2020
Cluster
C1
C2


C1
C2
Malta
Cyprus
Greece
Bulgaria
Portugal
Turkey
Lithuania
Romania
North Macedonia
Poland
Czechia
Serbia
Slovakia
Ukraine
Croatia
Bosnia and Herzegovina
Montenegro
Luxembourg
Italy
Iceland
Spain
Hungary
France
United Kingdom
Belgium
Norway
Ireland
Estonia
Slovenia
Netherlands
Israel
Sweden
Denmark
Finland
Austria
Switzerland
Germany
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250


C1
C2
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10
20
30
40
50
60
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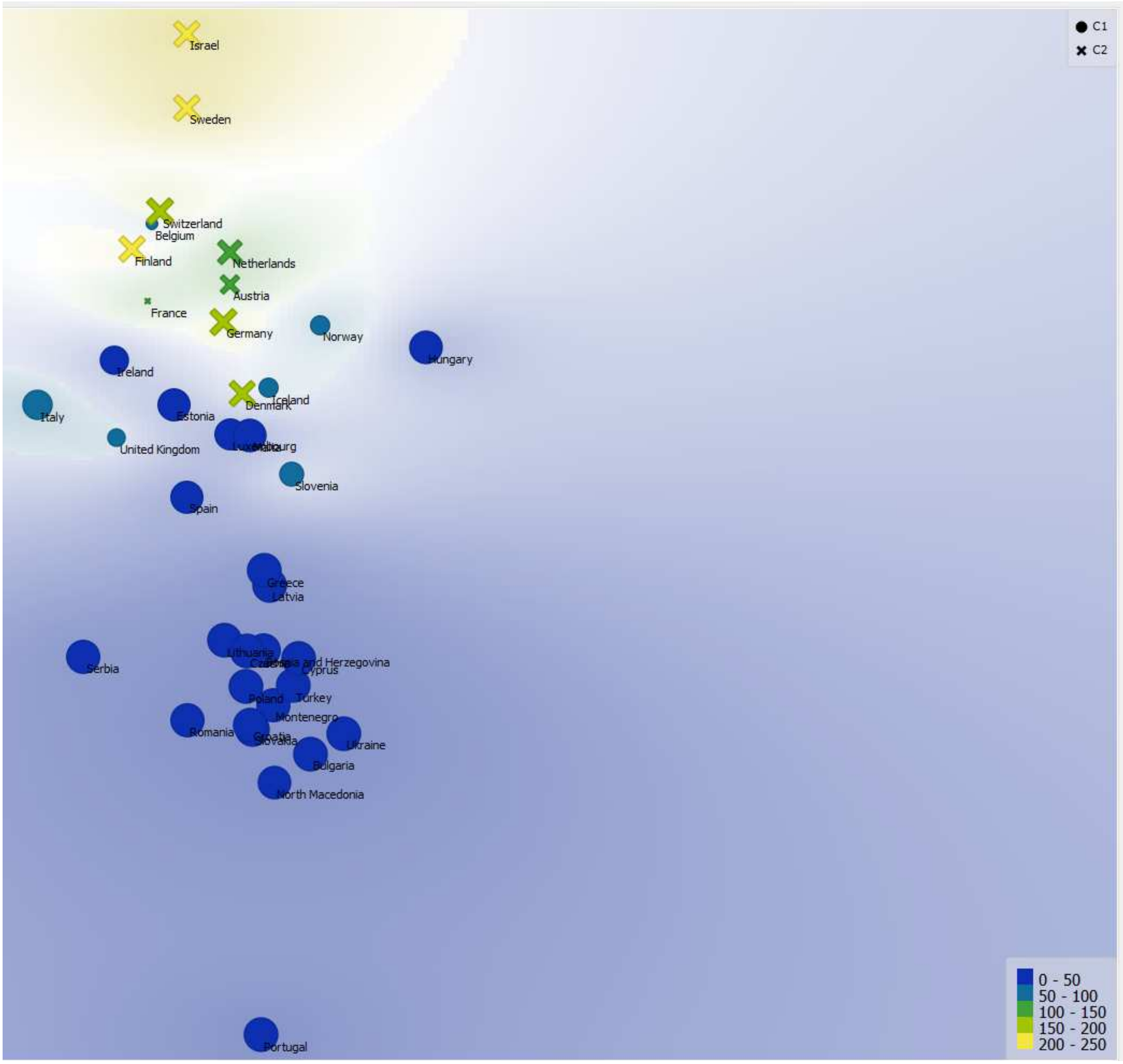
100


C1
C2
Israel
Sweden
Switzerland
Belgium
Finland
Netherlands
Austria
France
Germany
Norway
Hungary
Ireland
Italy
Estonia
Denmark
Iceland
United Kingdom
Slovenia
Spain
Greece
Latvia
Serbia
Lithuania
Cyprus
Poland
Turkey
Montenegro
Romania
Ukraine
Bulgaria
North Macedonia
Portugal
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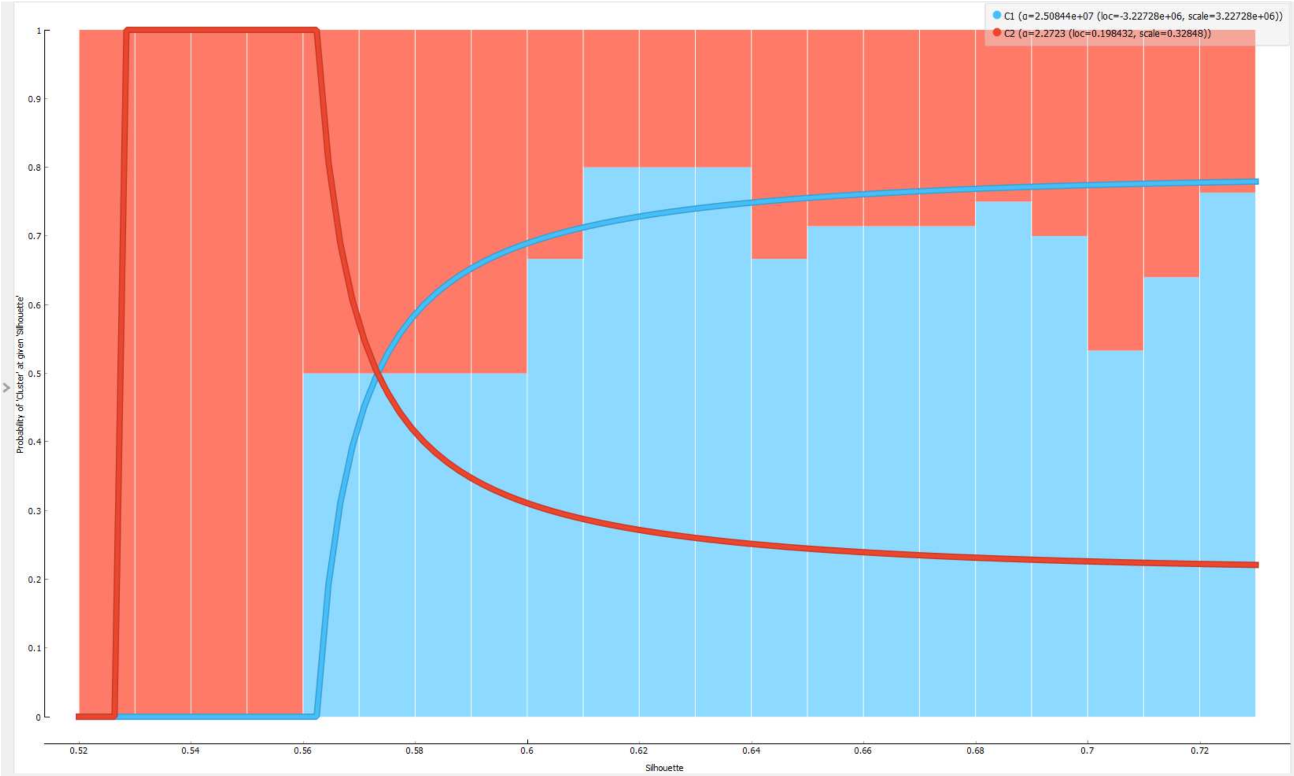
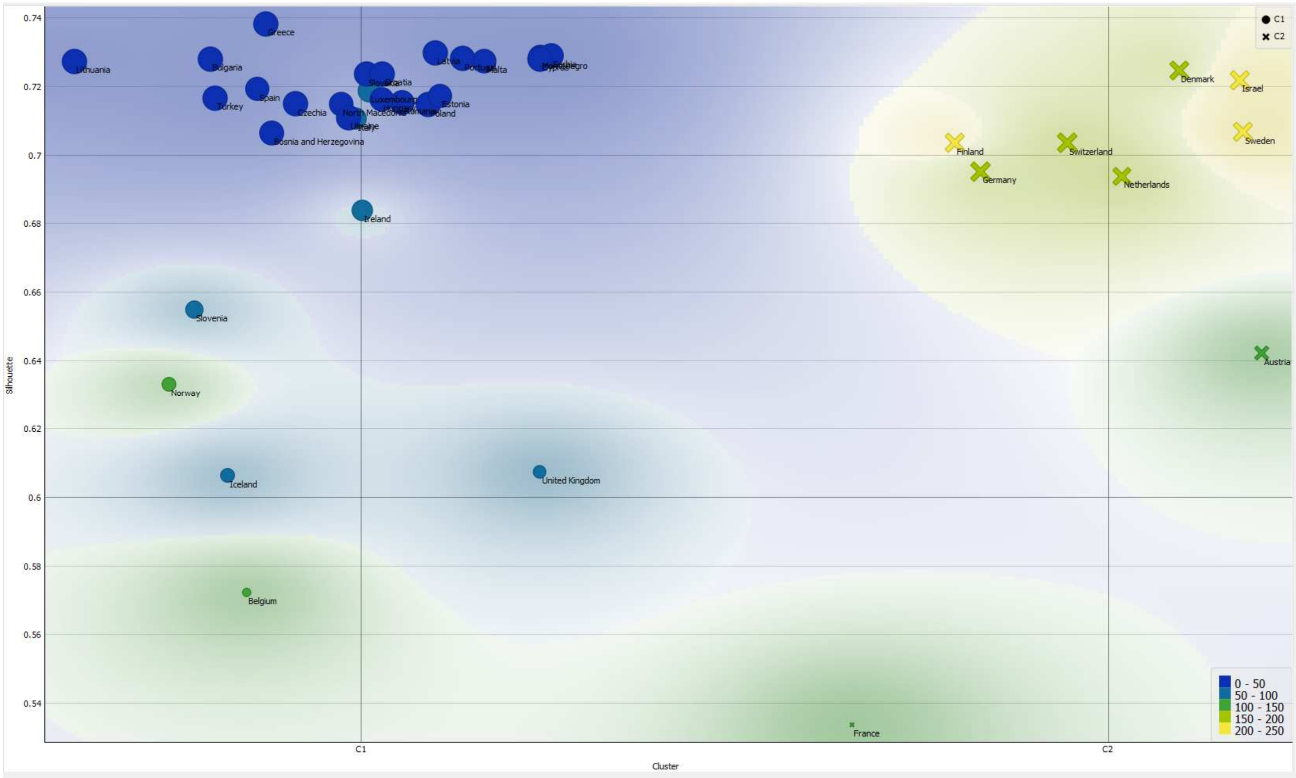
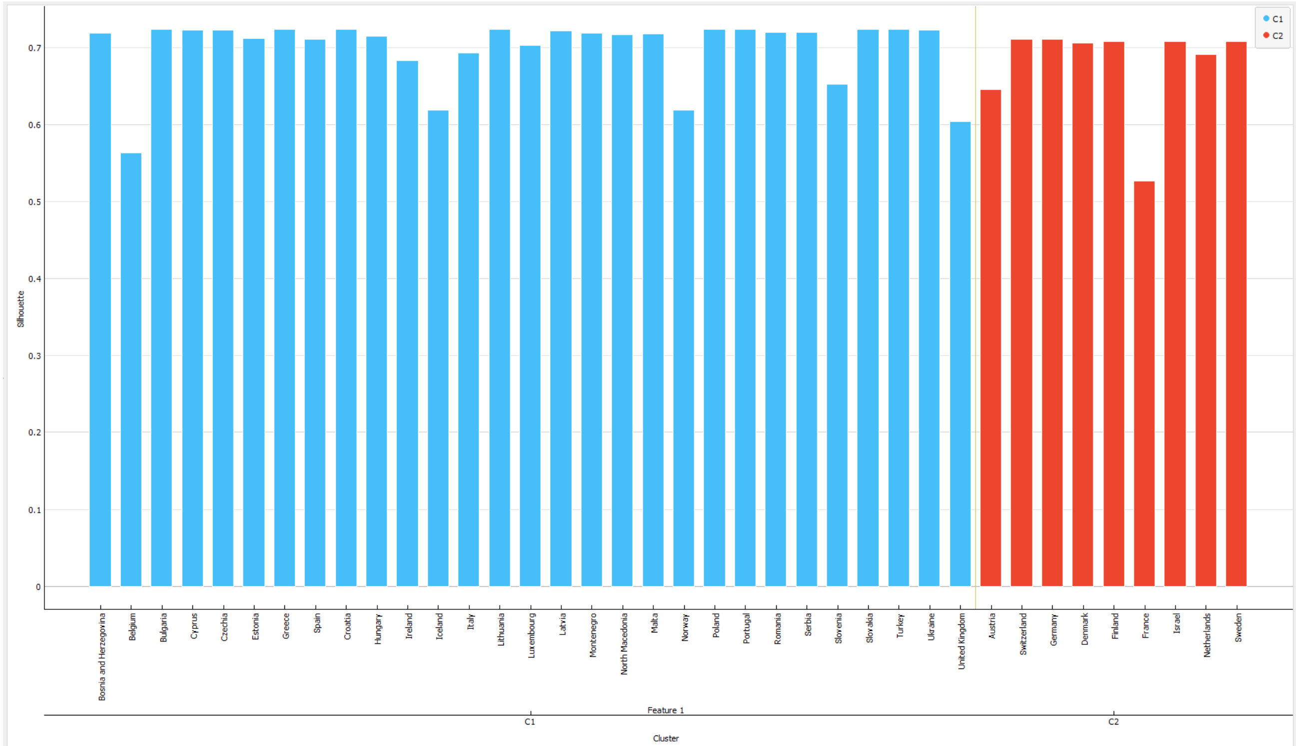
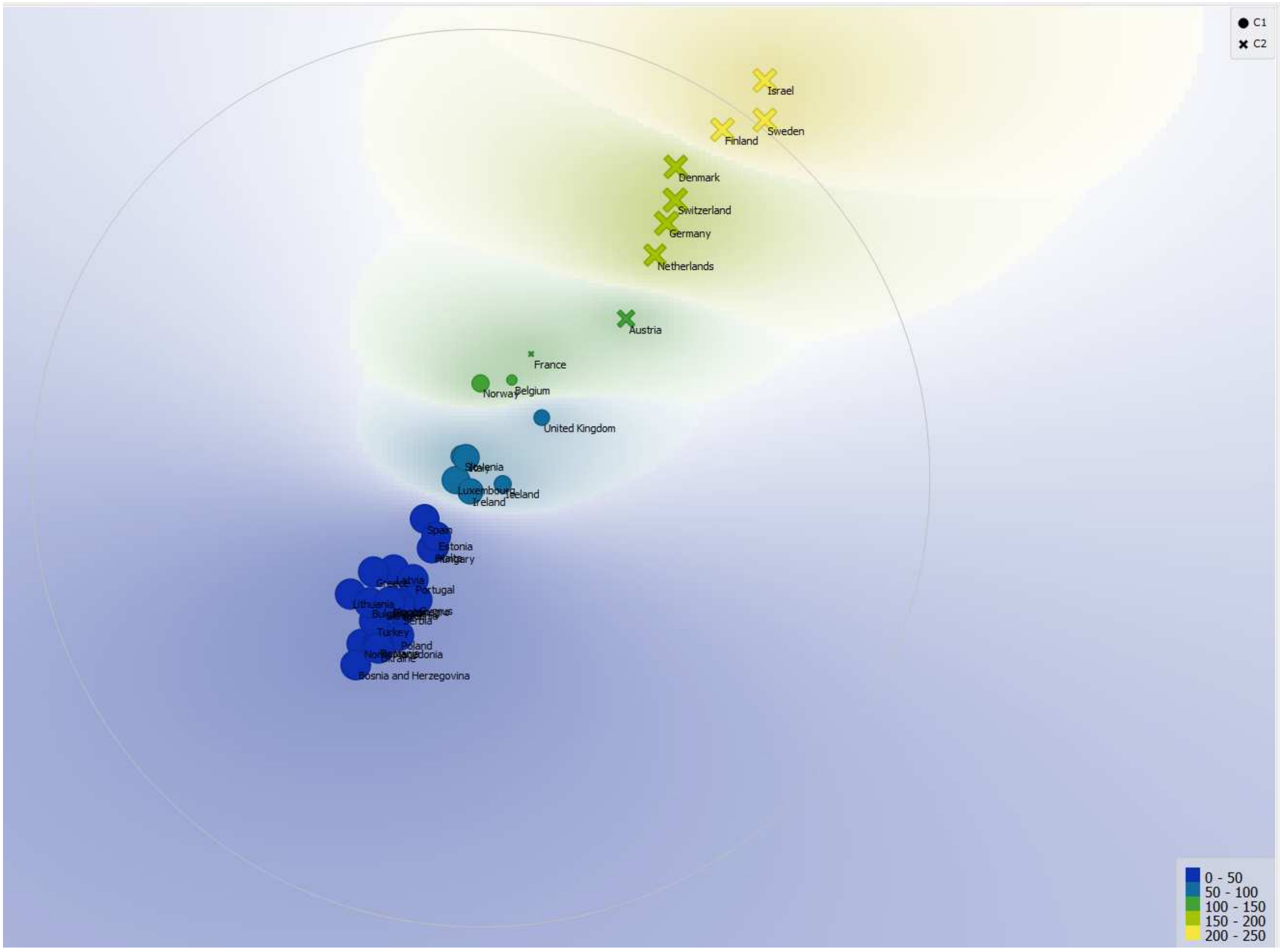
100 - 150
150 - 200
200 - 250


C1 (α=2.50844e+07 (loc=-3.22728e+06, scale=3.22728e+06))
C2 (α=2.2723 (loc=0.198432, scale=0.32848))
Probability of 'Cluster' at given 'Silhouette'
Silhouette


C1
C2
Greece
Lithuania
Bulgaria
Turkey
Spain
Czechia
Bosnia and Herzegovina
Latvia
Malta
Estonia
Luxembourg
North Macedonia
Ireland
Slovenia
Norway
Iceland
United Kingdom
Belgium
France
Denmark
Israel
Sweden
Finland
Switzerland
Germany
Netherlands
Austria
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
Silhouette
Cluster


C1
C2
Silhouette
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Bosnia and Herzegovina
Belgium
Bulgaria
Cyprus
Czechia
Estonia
Greece
Spain
Croatia
Hungary
Ireland
Iceland
Italy
Lithuania
Luxembourg
Latvia
Montenegro
North Macedonia
Malta
Norway
Poland
Portugal
Romania
Serbia
Slovenia
Slovakia
Turkey
Ukraine
United Kingdom
Austria
Switzerland
Germany
Denmark
Finland
France
Israel
Netherlands
Sweden
Feature 1
Cluster


C1
C2
Israel
Sweden
Finland
Denmark
Switzerland
Germany
Netherlands
Austria
France
Norway
Belgium
United Kingdom
Luxembourg
Ireland
Spain
Estonia
Portugal
Lithuania
Turkey
Poland
Bosnia and Herzegovina
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250