The Determinants of Lifelong Learning in Europe

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Abstract

The article affords the question of lifelong learning in Europe using data from the European Innovation Scoreboard-EIS in the period 2010-2019 for 36 countries. The econometric analysis is realized using WLS, Dynamic Panel, Pooled OLS, Panel Data with Fixed Effects and Random Effects. The results show that lifelong learning is, among other variables, positively associated to "*Human Resources*" and "*Government procurement of advanced technology products*" and is negatively associated, among others, to "*Average annual GDP growth*" and "*Innovation Index*". A clusterization is realized using the k-Means algorithm with a confrontation between the Elbow Method and the Silhouette Coefficient. Subsequently, a Network Analysis was applied with the distance of Manhattan. The results show the presence of 4 complex and 2 simplified network structures. Finally, a comparison was made among eight machine learning algorithms for the prediction of the value of lifelong learning. The results show that the linear regression is the best predictor algorithm and that the level of lifelong learning is expected to growth on average by 1.12%.

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 consider lifelong learning in connection with the ability of European countries to be competitive in terms of technological innovation. lifelong learning is in fact an essential element both to guide human capital towards the acquisition of new skills and competences in the field of knowledge-based economics, and to create an environment conducive to innovation that can support the intangible economy. It should be considered that lifelong learning is more relevant in terms of technological innovation as it allows for the generation of knowledge relating to digitization. Therefore, the diffusion of IT skills among the population is particularly relevant to generate positive effects in terms of technological innovation. Certainly, lifelong learning alone is not enough, we also need financial and political institutions capable of supporting investment in technological innovation in the long term. Finally, the presence of an entrepreneurial system that is able to promote the lifelong learning of workers and that also knows how to exploit the innovativeness of consumers to propose new products and services is very relevant.
Furthermore, it must be considered that in the context of the technological competition that pits China against the United States, Europe is far behind. In fact, the old continent is not sufficiently competitive in terms of technological innovation with respect to the USA and China. Investing in permanent learning alone certainly cannot be able to solve the question of the competitiveness of the European continent in terms of technological innovation. However, the development of specific economic policies for lifelong learning can help companies and workers to reinvent themselves quickly

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following market trends and acquiring the necessary mentality for the development of new products and services.
Finally, lifelong learning is also necessary from a political-institutional point of view. In fact, in order to function effectively, democratic regimes need a citizenry that is attentive and informed and capable of discussing technical and technological issues as well. In short, the orientation towards lifelong learning is certainly one of the levers that can make it possible to improve the labor market, increase the competitiveness of businesses and develop informed forms of active citizenship on the European continent.

2. Literature Review

[1] highlights the important role that new technologies play with reference to the formation of human capital in school and extra-school paths with a positive impact on lifelong learning. The authors particularly analyze the case of Romania. [2] analyze the ways in which education systems can actively participate in sustainable economic development determined at the regional level. In this sense the authors recognize a predominant role to lifelong learning. [3] refer to the role of lifelong learning as a factor capable of facilitating the application of new technologies in production systems for the creation of the innovative economy. [4] address the issue of lifelong learning for the elderly especially in the field of economic issues and communication. The authors address the issue of multimedia communication and the use of new technologies as lifelong learning tools for the elderly. [5] consider the role of MOOC platforms and online training in creating new skills and knowledge in the human capital employed in companies. The authors believe that the use of MOOCs can help support future levels of automation and digitization. The lifelong learning policies of the European Union can find a significant operational ally in MOOCs. [6] highlight the role of universities in creating a system based on Lifelong Learning. [7] consider the role of lifelong learning as a necessary element for the application of industry 4.0 and for the growth of competitiveness at the country level. The authors believe that the growth of lifelong learning is an essential element to ensure that competitiveness and productivity at the country level grow using new information technologies.[8] refer to the role of lifelong learning within the dynamics of change management achieved through company leadership. The authors believe that change leaders in companies are capable of gender changes in the corporate organizational structure using employee learning models of the lifelong learning type. [9] refer to the use of lifelong learning as a tool for decolonization and the fight against racism. The authors believe that through lifelong learning it is possible to fight cultural Eurocentrism. The institutionalization of Lifelong Learning paths can be useful to reduce racism and marginalization of immigrants especially in universities and workplaces. [10] address the issue of the application of lifelong learning in an interdisciplinary context. The authors believe that the dialogue between various social sciences and the choices of policy makers may be necessary to implement Lifelong Learning more efficiently with positive results in qualitative and quantitative terms.
[11] address the issue of the relationship between technological development and lifelong learning. The authors believe that the acquisition of new competences, knowledge, and skills in the field of industry 4.0 can only take place through a worker approach that is oriented towards lifelong learning. Lifelong learning is also necessary to carry out the retraining of workers. These reasons lead the authors to ask for a radical rethinking of educational and training models. [12] refer to the presence of a relationship between employee engagement and lifelong learning in the workplace. However, the authors wonder if the quality of working life and employee involvement truly generate a positive impact in terms of lifelong learning. The results show that increasing the quality of life and employee involvement have a positive impact in terms of lifelong learning. [13] propose the use of artificial intelligence as a tool to promote the spread of lifelong learning. [14] refer to the possibility of lifelong learning to create the conditions for creating a political culture that can avoid discrimination against women in the workplace. The authors made the case of South Africa. The results show that women can improve their working conditions through lifelong learning only if they also have the support of

an organizational culture favorable to gender parity. [15] refer to the use of lifelong learning as a tool to fight youth unemployment in Europe. In particular, the European Union, to combat youth unemployment produced by the financial crisis of 2007-2008, has focused on lifelong learning programs to ensure that young people are once again employable. However, the authors are critical that lifelong learning can truly be a tool capable of increasing the employability of young people in Europeans, especially in the absence of a clear modification of the structural arrangements of local labor markets. [16] analyze the role of lifelong learning in the context of policies aimed at strengthening human capital as a tool for increasing competitiveness at the country level, making the case of the Czech Republic. Permanent learning is also very useful for the elderly [17] . In this sense, the universities of the third age are essential tools to improve the learning of the elderly. The results show that seniors who engage in lifelong learning have above-average levels of socio-economic status.

From our point of view, Lifelong Learning is considered in the light of technological innovation. Company training in new technologies through an orientation towards the digitization of workers in the company [18]. Furthermore, Lifelong Learning can also have a role in boosting high tech exports of knowledge intensive services [19]. Countries that develop Lifelong Learning policies can also have positive impacts in terms of producing more intellectual assets as the population is more oriented towards the knowledge economy [20]. Furthermore, it is necessary that the investment in promotion policies for Lifelong Learning are also associated with programs for the development of internet networks [21]. In fact, Lifelong Learning acquires greater value in the presence of an orientation towards digitization. The spread of Lifelong Learning can also provoke a greater investment of companies in research and development activities [22]. In fact, the development of the knowledge economy, the presence of qualified human capital can also mobilize private investments. The spread of lifelong learning can also increase the innovativeness of small and medium-sized enterprises which can count on a social and cultural environment naturally oriented towards the creation of intangible assets [23]. The presence of human capital positively oriented to the creation of intangible assets can also push investors to support more investments in research and development [24].Furthermore, it is necessary to consider that the presence of economic policies aimed at promoting Lifelong Learning makes it possible to strengthen that innovation-friendly environment that allows companies to invest in research and development with significant effects in terms of productivity and competitiveness at the country level [25]. Companies may be more interested in investing in the creation of new products and services in the presence of a lifelong learning orientation of workers and consumers [26]. In fact, in this case, companies can count on a workforce capable of renewing their skills and on consumers capable of absorbing high degrees of product innovativeness. The presence of lifelong learning-oriented workers can also create the conditions for the foundation of new start-ups that attract the financial investment of venture capitalists and business angels [27]. Furthermore, the contribution of universities and research institutions in creating lifelong learning can also increase the attractiveness of national research systems [28]. Orientation to lifelong learning can increase the employability of workers in innovative companies [29]. Investing in Lifelong Learning can also make it possible to increase human capital at the country level by supporting investments in research and development and increasing company sales [30].

3. Econometric Model

We have estimated the determinants of Lifelong Learning for 36 European Countries in the period 2010-2019.

in the following formula:

$$\begin{aligned}\boldsymbol{LifeLongLearning}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{EnterprisesProvidingICTTraining})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{FinanceAndSupport})_{it} + \boldsymbol{b_3}(\boldsymbol{ForeignDoctorateStudents})_{it} \\ &+ \boldsymbol{b_4}(\boldsymbol{GovernmentProcurementOfAdvancedTechnologyProducts})_{it} \\ &+ \boldsymbol{b_5}(\boldsymbol{HumanResources})_{it} + \boldsymbol{b_6}(\boldsymbol{InnovationFriendlyEnvironment})_{it} \\ &+ \boldsymbol{b_7}(\boldsymbol{InnovativeSalesShare})_{it} \\ &+ \boldsymbol{b_8}(\boldsymbol{EmploymentInMediumAndHighTechProductExports}_{it} \\ &+ \boldsymbol{b_9}(\boldsymbol{NonR\&DInnovationExpenditure})_{it} \\ &+ \boldsymbol{b_{10}}(\boldsymbol{PublicPrivateCoPublication})_{it} \\ &+ \boldsymbol{b_{11}}(\boldsymbol{SMEsInnovatingInHouse})_{it} + \boldsymbol{b_{12}}(\boldsymbol{TrademarkApplications})_{it} \\ &+ \boldsymbol{b_{13}}(\boldsymbol{AverageAnnualGrowth})_{it} \\ &+ \boldsymbol{b_{14}}(\boldsymbol{BasicSchoolEntrepreneurialEducationAndTraining})_{it} \\ &+ \boldsymbol{b_{15}}(\boldsymbol{EmploymentMHTManufacturingKISServices})_{it} \\ &+ \boldsymbol{b_{16}}(\boldsymbol{FirmInvestments})_{it} + \boldsymbol{b_{17}}(\boldsymbol{NewDoctorateGraduates})_{it} \\ &+ \boldsymbol{b_{18}}(\boldsymbol{PrivateCoFundingOfPublicR\&DExpenditures})_{it} \\ &+ \boldsymbol{b_{19}}(\boldsymbol{TertiaryEducation})_{it}\end{aligned}$$

Where $i = 36$ ad $t = [2010; 2019]$

The econometric estimations show that the level of lifelong learning is positively associated with:

- *Enterprises providing ICT training:* is the number of companies that have provided IT training to their employees out of the total number of companies. There is therefore a positive relationship between the value of lifelong learning and the ability of companies to train their employees in the IT sector. This positive relationship can be understood considering that the investment that companies make in corporate human capital can be understood as a form of lifelong learning. In this case it is the company that takes care of the training of people and therefore makes up for the shortcomings of public institutions while pursuing its own profit objectives. The orientation towards lifelong learning is necessary to ensure that a real knowledge economy is determined which constitutes the environment in which the economy of technological innovation takes shape.
- *Finance and support:* it is a variable made up of a set of variables or R&D Expenditure in the public sector and Venture Capital Investment. The variable calculates the financial system's ability to support the system of technological innovation and research and development. There is a positive relationship between the value of lifelong learning and the value of financial support for technological innovation and research and development. this positive relationship can be understood considering that a large part of the investment in research and development and technological innovation is in fact an investment in human capital and in training and therefore in lifelong learning.
- *Foreign doctorate students:* is the number of PhD students from abroad. This variable refers to student mobility. Student mobility is an effective tool for disseminating knowledge. The presence of foreign PhD students guarantees the research system new human capital that can be used for technological innovation. There is a positive relationship between the value of PhD students from abroad and lifelong learning. In fact, the training activity of doctoral students which is part of tertiary education constitutes an element of lifelong learning.
- *Government procurement of advanced technology products*: it is an indicator that considers the extent to which public procurement decisions positively impact technological innovation. There is a positive relationship between the ability of public bodies to express a demand for technological innovation and lifelong learning. In fact, it is much more likely that a society characterized by a more widespread participation in lifelong learning also has a more positive

general orientation towards technological innovation. In this context, public bodies may also be able to express a demand for highly innovative technological services.

- *Human resources:* is an indicator that considers three different sub-variables: "New Doctorate Graduates", "Population Aged 25-34 with Completed Tertiary Education", "Population Aged 25-64 Involved in Education and Training". There is therefore a positive relationship between the value of Lifelong Learning and the value of Human Resources. This positive relationship can be better understood considering that Lifelong Learning is a variable that precisely considers the formation of human capital. The two variables therefore capture the same socio-economic phenomenon.
- *Innovation-friendly environment:* it is a variable consisting of the sum of two sub-variables namely "Broadband Penetration" and "Opportunity Driven Entrepreneurship. There is therefore a positive relationship between the value of Lifelong Learning and the value of the Innovation Friendly Environment. That is, the fact that countries have invested in the internet and have an entrepreneurial system capable of seizing market opportunities tends to be positively associated with the presence of a lifelong learning orientation of the population.
- *Innovative sales share:* it is a variable that considers the value of the turnover of new or significantly improved products as a percentage of the total number of companies. This variable includes both products that are new to the firm and products that are new to the market in general. There is therefore a positive relationship between the value of companies that make new or greatly improved products and the value of Lifelong Learning. Therefore, if a country system invests significantly in staff training, it follows that businesses can also have a positive impact by increasing their ability to be active and innovative. The innovation that companies can produce in the market is therefore not only a product of the company but also in a broader sense of the social climate in which the company operates. Countries that give greater importance to Lifelong Learning also have more innovative companies.
- *Employment in Medium and high-tech product exports:* it is a variable that considers employment in a set of sectors that are export-oriented such as manufacturing, high technology, pharmaceuticals, computers and information technology, aeronautics, electrical equipment. There is a positive relationship between employment in medium and high-tech companies that export and the spread of Lifelong Learning in the country. This positive relationship is essentially since the medium and high technology companies that export generally have a high-level human capital which can therefore be positively connected to the presence of lifelong learning at the country level.
- *Non-R&D innovation expenditure:* it is a variable that considers the value of the sum spent on innovation in companies with the exclusion of expenses not in research and development. This variable therefore considers only and exclusively the value of the innovation achieved using R&D expenses as a percentage of total turnover. For example, the investment in technological innovation achieved using the acquisition of various machinery and equipment. There is therefore a positive relationship between technological innovation and investment in Lifelong Learning. This relationship means that the countries in which there is more lifelong learning are also the countries in which companies invest more, even apart from investments in research and development.
- *Public-private co-publications:* it is an indicator of the number of public-private publications that shows the collaboration between researchers operating in the market and researchers operating for the public. Such cooperation between the public and private sectors in research results in scientific publications. There is a positive relationship between the value of Lifelong Learning and the value of public-private publications. This relationship indicates that in countries where there is greater investment in high-level training and greater capacity for cooperation between private companies and public institutions.
- *SMEs innovating in-house:* it is a variable that refers to the number of internal innovative companies that are defined as companies that have introduced product and process

innovations in collaboration with other companies and organizations. This indicator refers to SMEs or those companies that have several employees between 10 and 249. There is therefore a positive relationship between the value of innovative companies and investment in Lifelong Learning. In fact, the countries in which the most investment is made in terms of Lifelong Learning are also the most innovative countries in terms of product and process innovations.

- *Trademark applications:* is a variable that considers the number of trademark applications filed with the European Union Intellectual Property Office. This variable therefore refers to the ability of countries to innovate through brands. Brands are an important tool of technological innovation, especially in services. This trademark allows companies to use the tools in all Member States of the European Union. The trademark identifies the origin of goods and services, guarantees the quality of the product towards the consumer, constitutes a recognizable element in the forms of communication and advertising. There is therefore a positive relationship between the value of Lifelong Learning and the value of investing in brands at country level. That is, the countries that invest the most in the formation of human capital are also those that have the best results in terms of trademark applications. This relationship allows us to grasp the significance of technological innovation and the economy of knowledge as a widespread dimension that brings benefits to businesses, individuals, and institutions.

The econometric estimations show that the level of lifelong learning is negatively associated with:

- *Average Annual GDP growth:* it is an indicator that considers the growth of gross domestic product on average. There is a negative relationship between the value of the trend in gross domestic product on average and the value of Lifelong Learning. This relationship can be better understood considering that the gross domestic product tends to grow more for the countries that are more backward and therefore also have a lower endowment of Lifelong Learning. For example, that the countries of Eastern Europe have grown very pure without having a high level of Lifelong Learning. It follows that in this case the trend of GDP does not allow us to analyze the dynamics inherent in human capital and in the formation of the knowledge economy.
- *Basic-school entrepreneurial education and training:* measures the extent to which training in the creation or management of SMEs is incorporated into the education and training system at primary and secondary school level. There is therefore a negative relationship between this value and the value of Lifelong Learning. It is possible to understand this negative relationship considering that while entrepreneurship education in schools obviously concerns students of school age, the approach to Lifelong Learning instead concerns a population having a higher age. It is therefore not certain that a country that invests in student entrepreneurship is also able to guarantee a long-term approach to training in the life of its citizens.
- *Employment MHT manufacturing KIS services:* employment in technology and knowledge-intensive sectors nationwide. There is a negative relationship between the value of employment in knowledge-intensive technology sectors at national level and the value of Lifelong Learning. This relationship appears to be counterfactual. However, it must be considered that there are countries that produce products of high manufacturing value even without investing in lifelong learning. These are, for example, the countries in which it has relocated to escape international competition.
- *Firm investments:* These are investments that companies make in research and development, in the development of innovations and in strengthening the efforts of companies in terms of Information Communication Technology. There is a negative relationship between these types of investments and the value of Lifelong Learning. This negative relationship can be better understood considering that while the investment of companies in research and technological innovation concerns only their employees, on the contrary the investment in Lifelong Learning concerns society. And in this sense, obviously, the fact that companies

invest in the training of their employees may not have the necessary impact to steer the entire society towards the knowledge economy through Lifelong Learning.

- *Innovation index:* is an indicator of a country's overall ability to innovate. There is a negative relationship between Lifelong Learning and the value of the Innovation Index. This negative relationship means that Lifelong Learning does not have a significant impact in determining the innovation conditions at the country level. It follows that Lifelong Learning is a condition of context which, however, could not generate a direct impact in terms of the technological innovativeness of companies, products and services.
- *New doctorate graduates:* it is an indicator who considers people with a second -level university formation in age between 25 and 34 years. The data show the presence of a negative relationship between the value of new graduates and the value of lifelong learning. That is, not necessarily the countries operating with Lifelong Learning policies are also able to generate a growth in the number of second level graduates of university matrix. Obviously, although lifelong learning is certainly relevant at a social, economic, and political level, it is also necessary to underline that university formal study paths are certainly more relevant.
- *Private co-funding of public R&D expenditures:* it is a variable that considers the research and development costs that companies finance in the public. This indicator therefore measures the amount of public-private cooperation. This report expresses a specific orientation of research and development that having been financed by companies is increasingly close to the needs of industry. There is a negative relationship between the value of lifelong learning and the value of private investment in the research carried out by public bodies. This negative relationship can be better understood considering that the fact that a company finishes research to a public body has nothing to do with the fact that the entire population of that nation is oriented towards the economy of knowledge with continuous training programs aimed at adults.
- *Tertiary education:* is the percentage of people with one age between 25 and 34 years having a tertiary education. It is an advanced general skills indicator. Variable does not refer only to the STEM disciplines or technical-scientific fields. There is a negative relationship between the number of people who have a Tertiary Education type qualification and the Edel Lifelong Learning valor in Europe. This negative relationship stands out that the presence of research doctorates and high professionalism is not necessarily accompanied by the presence of programs for lifelong learning at national level.

Econometric Estimations of Lifelong Learning							
		WLS	*Dynamic Panel*	*Pooled OLS*	*Fixed Effects*	*Random Effects*	
	A32	*Coefficient and p-Value*	*Coefficient and p-Value*	*Coefficient and p-Value*	*Coefficient and p-Value*	*Coefficient and p-Value*	*Average*
Constant		-0,301657	-2,89901***	-0,884907	-0,117227	-0,221777	-0,8849
Average Annual GDP growth	A2	-5,28751	-2,61121***	-6,62813***	-5,22935***	-5,38303***	-5,0278
Basic-school entrepreneurial education and training	A4	-0,456114 ***	-0,614517***	-0,40619***	-0,384467***	-0,388624***	-0,45
Employment MHT manufacturing KIS services	A11	-0,365435 ***	-0,196152*	-0,316996***	-0,301216***	-0,310829***	-0,2981
Enterprises providing ICT training	A15	0,145641***	0,140476*	0,124765***	0,129128***	0,128288***	0,13366
Finance and support	A17	0,309646***	0,206638***	0,495175***	0,239702***	0,261254***	0,30248
Firm investments	A18	-0,458598***	-0,425916**	-0,343673***	-0,431704***	-0,422961***	-0,4166
Foreign doctorate students	A19	0,158934***	0,102913**	0,128222***	0,134413***	0,134298***	0,13176
Government procurement of advanced technology products	A22	2,64442***	2,157***	2,96687***	2,36671***	2,43037***	2,51307
Human resources	A23	2,4533***	2,09951***	2,12949***	2,1676***	2,17311***	2,2046
Innovation index	A24	-1,13503***	-0,846112***	-1,45274***	-0,970757***	-1,01691***	-1,0843
Innovation-friendly environment	A25	0,0603056**	0,126286**	0,109497***	0,0605989**	0,0647107**	0,08428
Innovative sales share	A26	0,137165***	0,0865422**	0,172892***	0,123507***	0,127072***	0,12944
Medium and high-tech product exports	A35	0,226112***	0,268367***	0,310804***	0,270102***	0,27734***	0,27055
New doctorate graduates	A37	-0,680338***	-0,568418***	-0,526936***	-0,593602***	-0,589056***	-0,5917
Non-R&D innovation expenditure	A38	0,215035***	0,170142**	0,162683***	0,163784***	0,163172***	0,17496
Private co-funding of public R&D expenditures	A43	-0,210868***	-0,195762**	-0,29897***	-0,19283***	-0,204905***	-0,2207
Public-private co-publications	A45	0,292351***	0,260138***	0,306284***	0,28975***	0,291664***	0,28804
SMEs innovating in-house	A52	0,284019***	0,197863***	0,324087***	0,274303***	0,282972***	0,27265
Tertiary education	A53	-0,709618***	-0,564285***	-0,571989***	-0,586842***	-0,587529***	-0,6041
Trademark applications	A56	0,210685***	0,127375**	0,224912***	0,182454***	0,188598***	0,1868
Lifelong Learning	A32		0,0476886				

Figure 1. Risultati della stima econometrica realizzata per l'analisi del valore del Lifelong Learning.

4. Clusterization with k-Means: Silhouette vs. Elbow Method

We realize a clusterization with the k-Means algorithm. Using the silhouette coefficient two different Clusters have been identified. The Clusters are indicated below or:

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

By calculating the value of the median of individual Clusters it is possible to verify that the value of the clusterization for the 1-C1 cluster is equal to an amount of 55.56 units while the median value of the 2-C2 cluster is equal to an amount of 210.56. It follows that the 2-C2 Cluster countries have a higher lifelong learning value than the 1-C1 cluster countries of an amount of 378%. However, comparing the clusterization with the silhouette coefficient with the Elbow method, it turns out that while in the case of the silhouette coefficient two Clusters are indicated in the case of the Elbow method are identified four Clusters. Therefore, by applying the Elbow method, the following Clusters are identified or:

- *Cluster 1*: Montenegro, Croatia, Slovakia, Northern Macedonia, Bulgaria, Greece, Romania, Serbia, Poland, Turkey, Lithuania;
- *Cluster 2*: Luxembourg, France, Netherlands, United Kingdom, Norway, Austria, Estonia;
- *Cluster 3*: Sweden, Switzerland, Denmark, Finland, Iceland
- *Cluster 4*: Portugal, Spain, Czech Republic, Belgium, Malta, Ireland, Germany, Italy, Cyprus, Slovenia, Hungary, Latvia.

To identify the system of clusters, the median value of the Clusters for the value of the lifelong learning is used. It appears that the median value of the 3-C3 cluster is equal to an amount of 306.67, the median value of the 2-C2 cluster is equal to an amount of 204.44 units, the median value of the 4-C4 cluster It is equal to an amount of 81.11, while the value of the 1-C1 cluster is equal to 30.00. It therefore follows that the Clusters system consists of C3 = 306.67> C2 = 204.44> C4 = 81.11> C1 = 30.00.

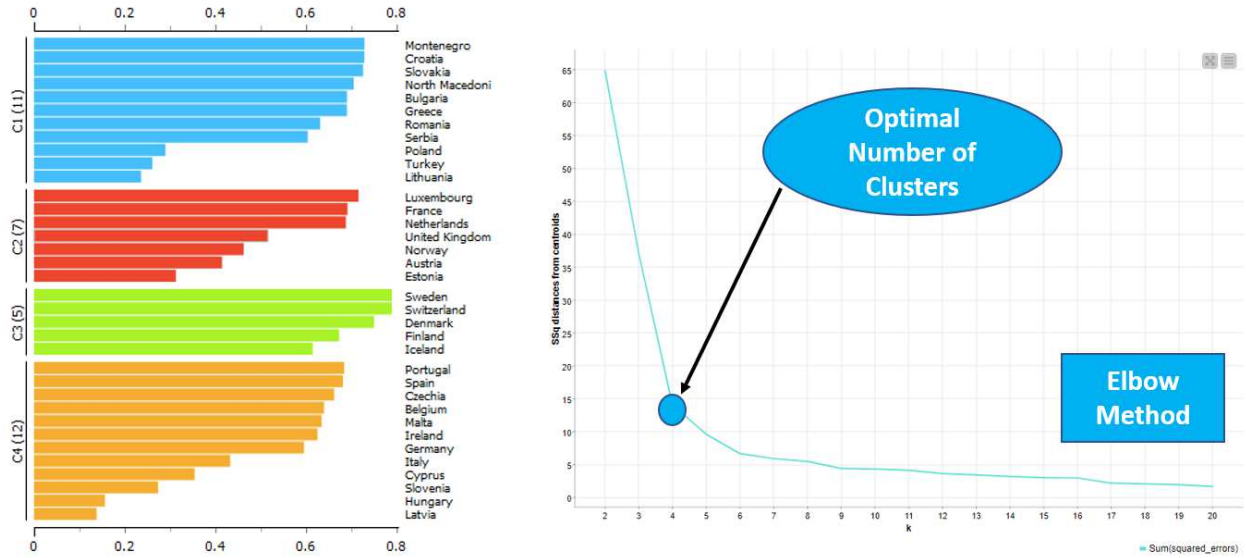

Figure 2. Optimization of the number of Clusters with the Elbow method and indication of the composition of the Clusters.

From a strictly geographical point of view, it is possible to verify a dominance of the areas of northern Europe, especially Scandinavian, compared to southern Europe and Eastern Europe. It should be considered that the significant difference in terms of lifelong learning is at the same time causes and consequence of the economic gap in terms of GDP between north and southern Europe. In fact, in the context of the economy of knowledge it is necessary to invest in the lifelong learning to increase the competitive capacity in the production of high-quality intangibles.

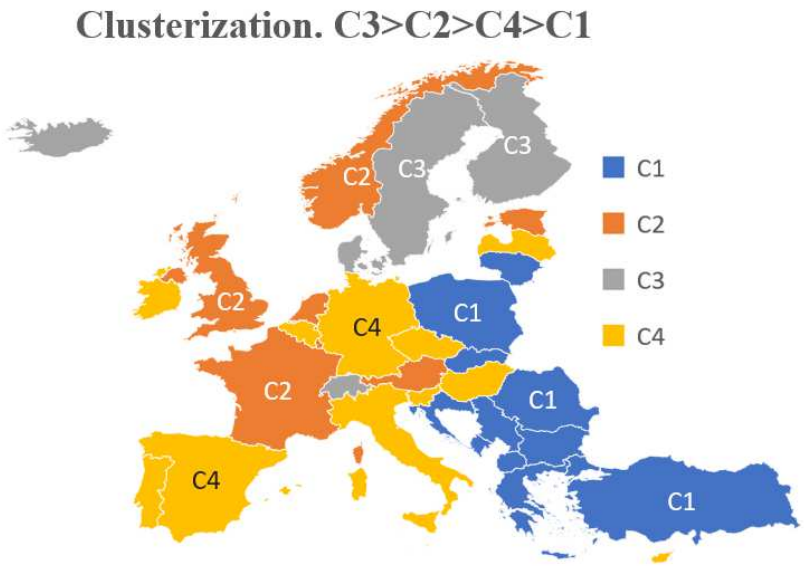

Figure 3. Geographical representation of the Cluster structure optimized with the Elbow method.

5. Network Analysis with the use of Manhattan distance method

A Network Analysis is presented below using Manhattan's distance. Four structures are identified with complex network structures and two structures with simplified networks or consisting of the biunivocal relationship between two nations.

There is a complex network structure consisting of Bulgaria, Montenegro, Croatia, Northern Macedonia, Slovakia, Greece. In particular, the following connections exist:

- Greece has a connection with Slovakia on a link value of 0.15;
- Slovakia has a connection with Greece equal to an amount of 0.15, with Croatia for a value equal to0.14, with Northern Macedonia with a value of 0.2, with Montenegro for an equal value at 0.11;
- Northern Macedonia has a connection with Croatia for a value of 0.12, with Slovakia for a value of 0.2, with Montenegro for a value of 0.2;
- Montenegro has a connection with North Macedonia equal to a value of 0.2, with Slovakia for a value of 0.11 and with Croatia equal to 0.1;
- Croatia has a connection with North Macedonia equal to an amount of 0.12, with Montenegro equal to an amount of 0.1 and with Slovakia for a value equal to 0.14.

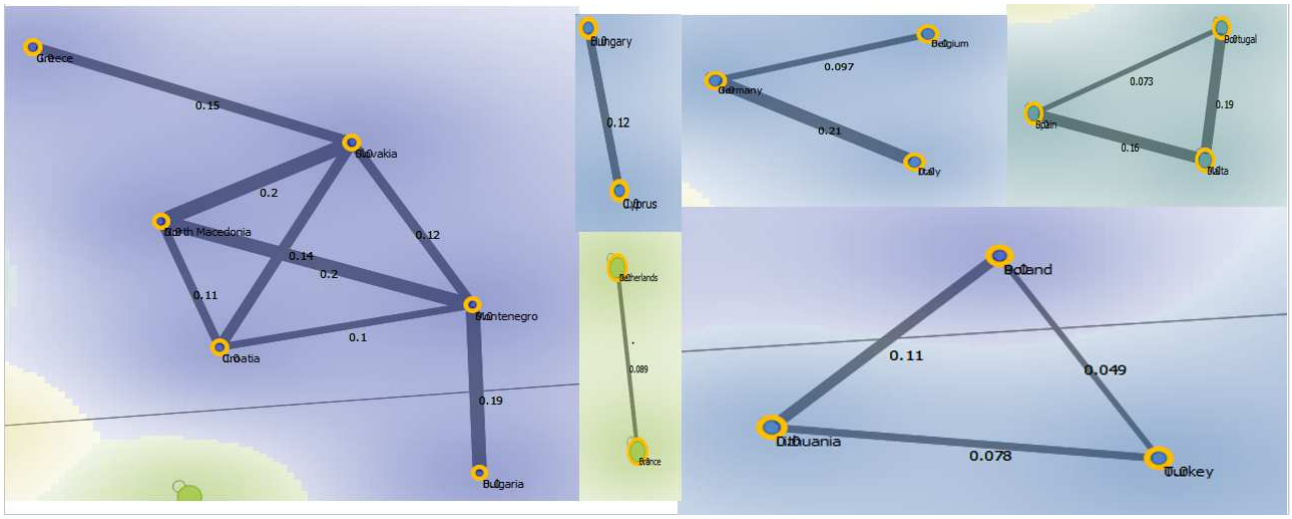

Figure 4. Network structures detected through the use of Manhattan's distance.

There is a complex network structure between Germany, Belgium and Italy. Particularly:

- Germany has a connection with Belgium for a value equal to 0.097 and with Italy for a value equal to0,21;
- Belgium has a connection with Germany equal to an amount of 0.97;
- Italy has a connection with Germany equal to an amount of 0.21.

There is a complex network structure between Spain, Portugal, and Malta. Particularly

- Portugal has a connection with Malta for a value of 0.19 and with Spain for a value of 0.073;
- Spain has a connection with Portugal for a value of 0.073 units and with Italy for a value of 0.16 units;
- Italy has a connection with Spain for a value of 0.16 units and with Portugal with a value of 0.19 units.

There is a complex network structure between Turkey, Poland and Lithuania as indicated below or:

- Poland has a connection with Turkey for a value of 0.049 and with Lithuania for a value of 0.11;
- Lithuania has a connection with Poland equal to an amount of 0.11 units and with Turkey for a value of 0.078;
- Turkey has a connection with Poland for a value of 0.49 and with Lithuania with a value of 0.078.

There are also two structures with simplified networks relationships between two nations. These reports are indicated below:

- Hungary has a connection with Cyprus for a value of 0.12;
- The Netherlands has a relationship with France for a value of 0.08.

6. Machine Learning and Prediction

A prediction was later created through a comparison between eight different Machine Learning algorithms. The algorithms were compared in terms of the maximization of the R-Squared and minimization of statistical errors. The learning rate was placed at 70%. The analysis showed the presence of the following system between the algorithms or:

- Linear Regression with a payoff equal to 4;
- Tree ensemble with a payoff equal to 9;
- PNN-Probabilistic neural Network with a payoff equal to 12;
- Polynomial Regression with a payoff value of 15;
- Simple Regression Tree with a payoff value of 20;
- Random Forest Regression with a payoff value of 25;

- Gradient Boosted Trees Learner with a payoff value of 27;
- ANN-Artificial Neural Network with a payoff value of 32.

Using the most performing algorithm or the linear regression it is possible to create the following predictions or:

- Austria with an increased variation from an amount of 153.333 to a valley of 159.21 units or a variation of 5.88 units equal to a value of 3.83%;
- Belgium with an increased variation from an amount of 81.111 units up to a value of 85.339 units or equal to a variation of 4.22 units equal to a modernization of 5.21%;
- Switzerland with an increased variation from an amount of 306,667 units up to a value of 319.06 with a variation of 12.39 units and 4.04%;
- Finland with a variation from a value of 306.6 units up to a value of 315.74 units or a variation of 9.0 units equal to an amount of 2.95%;
- France with a diminutive variation from an amount of 206.66 units up to a value of 204.65 units or equal to a variation of -2.011 units equal to an amount of 0.973%;
- Croatia with an increased variation from an amount of 28.88 units up to a value of 22.27 units equal to an amount of -6.61 units equal to a value of -22.89%;
- Montenegro with a variation from an amount of 17.77 units up to a value of 26.33 units or equal to a variation of 8.55 units equal to an amount of 48.14%;
- North Macedonia with a diminutive variation from an amount of 21.11 units up to a value of 17.55 units or equal to a variation of -3.56 units or equal to a variation of -16.86%;
- Norway with an increased variation from an amount of 204.44 units up to an amount of 217.48 units or equal to a variation of 13.04 units equal to an amount of 6.38%;
- Slovenia with a variation from an amount of 144.44 units up to a value of 115.340 units or a variation equal to an amount of -29.1 units equal to a variation -20.14%;
- UK with a variation from an amount of 53.33 units up to a value of 58.64 or equal to a variation of 5.3 units equal to an amount of 9.95%.

Statistical Results of Machine Learning Algorithms

	ANN	*PNN*	*Simple Regression Tree*	*Gradient Boosted Trees Learner*
R^2	0,844491410	0,982566447	0,969303855	0,923752741
Mean absolute error	0,097877646	0,030594794	0,052740427	0,064858533
Mean squared error	0,015510759	0,001708686	0,004955870	0,011396215
Root mean squared error	0,124542199	0,041336259	0,070397943	0,106753058
	Random Forest Regression	*Tree Ensemble*	*Linear Regression*	*Polynomial Regression*
R^2	0,895540577	0,980104815	0,997628039	0,976449952
Mean absolute error	0,060092493	0,024679254	0,014038691	0,028968173
Mean squared error	0,007332816	0,001615010	0,000000000	0,002954123
Root mean squared error	0,085631860	0,040187186	0,017401115	0,054351847

Using the best predictor algorithm or the linear regression considering the countries for which prediction is available, it is a growth of the value estimated from an amount of 138.58 up to a value of 140.15 units or a variation of 1.56 Unit equal to an amount of 1.12%.

7. Conclusions

The role of lifelong learning with respect to technological innovation has been analyzed in this article. The reference data were acquired through the database of the European Innovation Scoreboard of the European Commission. Data from 36 countries over the period 2010-2019 were analyzed. Lifelong learning is positively associated with human capital and negatively associated with average GDP growth, among other variables. From the point of view of clustering, the dominance of the Scandinavian countries in terms of lifelong learning is evident compared to other European countries. Predictive algorithms identify a growing trend of lifelong learning in Europe.

From a political and economic point of view, it is necessary to consider that investment in lifelong learning is essential to ensure that Europe catches up with the USA and China in the technological competition. In fact, Europe is very backward in the new technologies of industry 4.0 both from the point of view of the preparation of workers and from the point of view of the innovative capacity of companies. Furthermore, the degree of innovativeness of consumers is also quite low. It follows that investment in lifelong learning can help workers to increase skills and companies to be more oriented towards technological innovation. However, lifelong learning alone is obviously not enough and must be accompanied by profound and structural reforms of the labor markets, vocational training and incentives for business innovation.

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 and/or submission, and redundancies have been completely observed by the authors.

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10. Appendix

Econometric Estimations of Lifelong Learning							
		WLS	***Dynamic Panel***	***Pooled OLS***	***Fixed Effects***	***Random Effects***	
	A32	***Coefficient and p-Value***	***Coefficient and p-Value***	***Coefficient and p-Value***	***Coefficient and p-Value***	***Coefficient and p-Value***	***Average***
Constant		-0,301657	-2,89901***	-0,884907	-0,117227	-0,221777	-0,8849
Average Annual GDP growth	A2	-5,28751	-2,61121***	-6,62813***	-5,22935***	-5,38303***	-5,0278

Basic-school entrepreneurial education and training	A4	-0,456114 ***	-0,614517***	-0,40619***	-0,384467***	-0,388624***	-0,45
Employment MHT manufacturing KIS services	A11	-0,365435 ***	-0,196152*	-0,316996***	-0,301216***	-0,310829***	-0,2981
Enterprises providing ICT training	A15	0,145641***	0,140476*	0,124765***	0,129128***	0,128288***	0,13366
Finance and support	A17	0,309646***	0,206638***	0,495175***	0,239702***	0,261254***	0,30248
Firm investments	A18	-0,458598***	-0,425916**	-0,343673***	-0,431704***	-0,422961***	-0,4166
Foreign doctorate students	A19	0,158934***	0,102913**	0,128222***	0,134413***	0,134298***	0,13176
Government procurement of advanced technology products	A22	2,64442***	2,157***	2,96687***	2,36671***	2,43037***	2,51307
Human resources	A23	2,4533***	2,09951***	2,12949***	2,1676***	2,17311***	2,2046
Innovation index	A24	-1,13503***	-0,846112***	-1,45274***	-0,970757***	-1,01691***	-1,0843
Innovation-friendly environment	A25	0,0603056**	0,126286**	0,109497***	0,0605989**	0,0647107**	0,08428
Innovative sales share	A26	0,137165***	0,0865422**	0,172892***	0,123507***	0,127072***	0,12944
Medium and high-tech product exports	A35	0,226112***	0,268367***	0,310804***	0,270102***	0,27734***	0,27055
New doctorate graduates	A37	-0,680338***	-0,568418***	-0,526936***	-0,593602***	-0,589056***	-0,5917
Non-R&D innovation expenditure	A38	0,215035***	0,170142**	0,162683***	0,163784***	0,163172***	0,17496
Private co-funding of public R&D expenditures	A43	-0,210868***	-0,195762**	-0,29897***	-0,19283***	-0,204905***	-0,2207
Public-private co-publications	A45	0,292351***	0,260138***	0,306284***	0,28975***	0,291664***	0,28804
SMEs innovating in-house	A52	0,284019***	0,197863***	0,324087***	0,274303***	0,282972***	0,27265
Tertiary education	A53	-0,709618***	-0,564285***	-0,571989***	-0,586842***	-0,587529***	-0,6041
Trademark applications	A56	0,210685***	0,127375**	0,224912***	0,182454***	0,188598***	0,1868
Lifelong Learning	A32		0,0476886				

Modello 1077: WLS, usando 358 osservazioni
Incluse 36 unità cross section
Variabile dipendente: A32
Pesi basati sulle varianze degli errori per unità

	Coefficiente	*Errore Std.*	*rapporto t*	*p-value*	
const	–0,301657	1,30109	–0,2318	0,8168	
A2	–5,28751	0,674923	–7,834	<0,0001	***
A4	–0,456114	0,0395485	–11,53	<0,0001	***
A11	–0,365435	0,0370039	–9,876	<0,0001	***

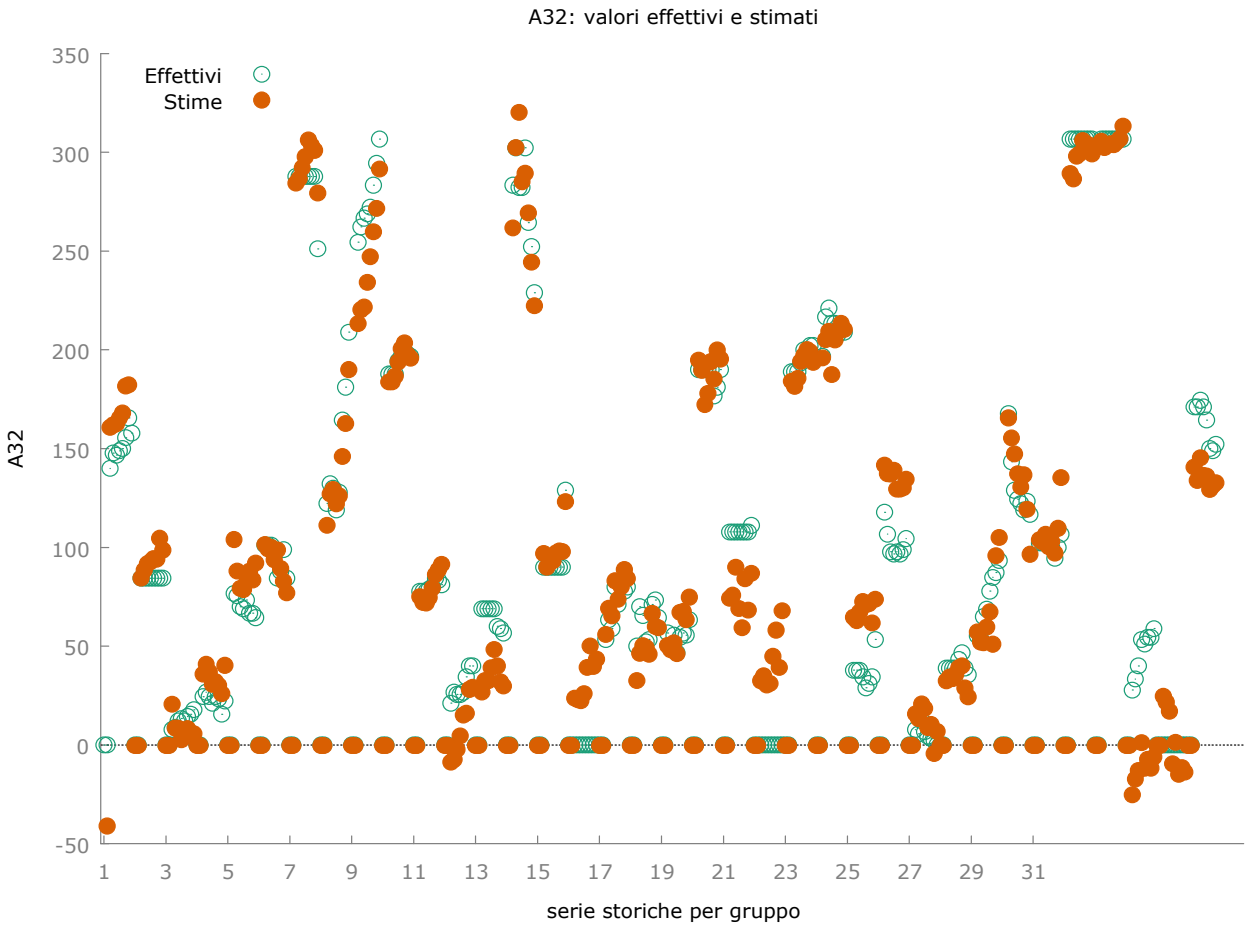
A15	0,145641	0,0166901	8,726	<0,0001	***
A17	0,309646	0,0391203	7,915	<0,0001	***
A18	–0,458598	0,0412767	–11,11	<0,0001	***
A19	0,158934	0,0159046	9,993	<0,0001	***
A22	2,64442	0,217100	12,18	<0,0001	***
A23	2,45330	0,0780205	31,44	<0,0001	***
A24	–1,13503	0,156933	–7,233	<0,0001	***
A25	0,0603056	0,0241769	2,494	0,0131	**
A26	0,137165	0,0265510	5,166	<0,0001	***
A35	0,226112	0,0320144	7,063	<0,0001	***
A37	–0,680338	0,0360883	–18,85	<0,0001	***
A38	0,215035	0,0195994	10,97	<0,0001	***
A43	–0,210868	0,0322318	–6,542	<0,0001	***
A45	0,292351	0,0191380	15,28	<0,0001	***
A52	0,284019	0,0352619	8,055	<0,0001	***
A53	–0,709618	0,0305864	–23,20	<0,0001	***
A56	0,210685	0,0219943	9,579	<0,0001	***

Statistiche basate sui dati ponderati:

Somma quadr. residui	293,7075	E.S. della regressione	0,933561
R-quadro	0,986599	R-quadro corretto	0,985804
F(20, 337)	1240,534	P-value(F)	9,2e-302
Log-verosimiglianza	–472,5472	Criterio di Akaike	987,0944
Criterio di Schwarz	1068,586	Hannan-Quinn	1019,504

Statistiche basate sui dati originali:

Media var. dipendente	90,83264	SQM var. dipendente	93,71702
Somma quadr. residui	133403,3	E.S. della regressione	19,89612



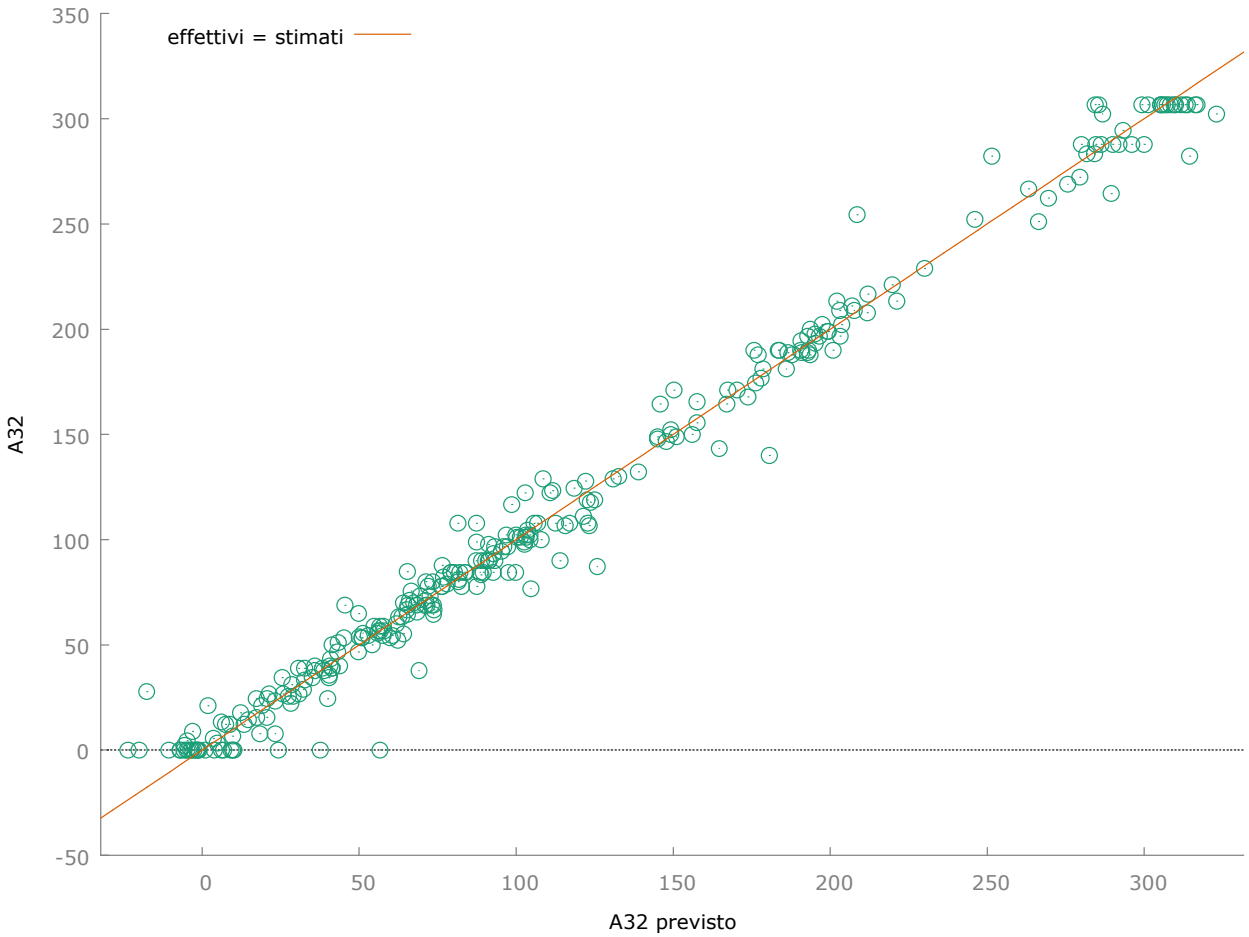
Modello 1078: Panel dinamico a un passo, usando 287 osservazioni
Incluse 36 unità cross section
Lunghezza serie storiche: minimo 7, massimo 8
Matrice H conforme ad Ox/DPD
Variabile dipendente: A32

	Coefficiente	*Errore Std.*	*z*	*p-value*	
A32(-1)	0,0476886	0,0346961	1,374	0,1693	
const	−2,89901	0,864722	−3,353	0,0008	***
A2	−2,61121	0,575816	−4,535	<0,0001	***
A4	−0,614517	0,109841	−5,595	<0,0001	***
A11	−0,196152	0,102518	−1,913	0,0557	*
A15	0,140476	0,0740172	1,898	0,0577	*
A17	0,206638	0,0735887	2,808	0,0050	***
A18	−0,425916	0,203055	−2,098	0,0359	**
A19	0,102913	0,0464581	2,215	0,0267	**
A22	2,15700	0,474675	4,544	<0,0001	***
A23	2,09951	0,328414	6,393	<0,0001	***
A24	−0,846112	0,298488	−2,835	0,0046	***
A25	0,126286	0,0494619	2,553	0,0107	**
A26	0,0865422	0,0374728	2,309	0,0209	**

A35	0,268367	0,0934295	2,872	0,0041	***
A37	−0,568418	0,140128	−4,056	<0,0001	***
A38	0,170142	0,0755359	2,252	0,0243	**
A43	−0,195762	0,0820223	−2,387	0,0170	**
A45	0,260138	0,0639410	4,068	<0,0001	***
A52	0,197863	0,0576854	3,430	0,0006	***
A53	−0,564285	0,140178	−4,025	<0,0001	***
A56	0,127375	0,0643765	1,979	0,0479	**

Somma quadr. residui 33377,21 E.S. della regressione 11,22282

Numero di strumenti = 42
Test per errori AR(1): z = -1,77142 [0,0765]
Test per errori AR(2): z = -1,33926 [0,1805]
Test di sovra-identificazione di Sargan: Chi-quadro(20) = 22,5824 [0,3098]
Test (congiunto) di Wald: Chi-quadro(21) = 33071,9 [0,0000]

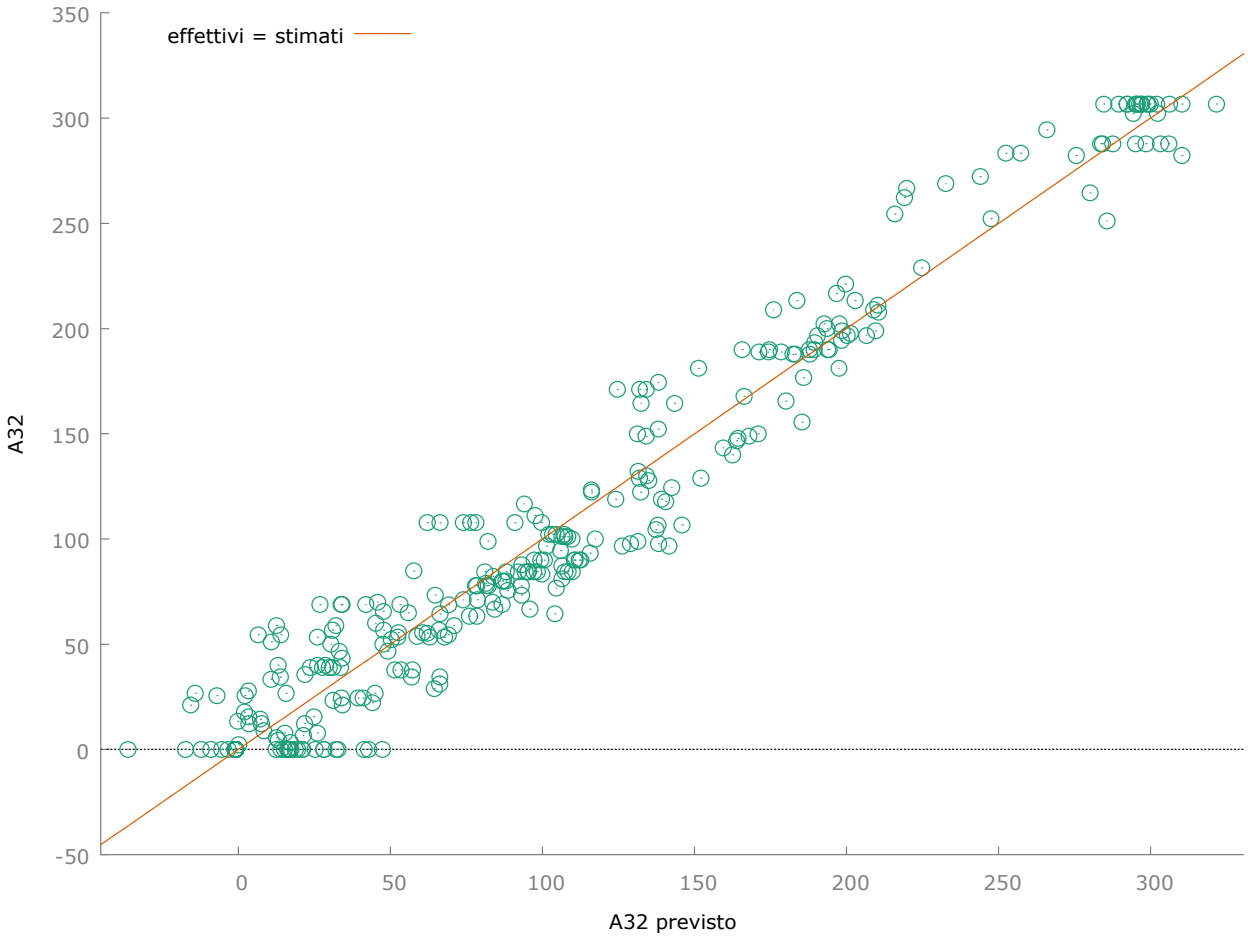


Modello 1079: Pooled OLS, usando 358 osservazioni
Incluse 36 unità cross section
Lunghezza serie storiche: minimo 8, massimo 10

Variabile dipendente: A32

	Coefficiente	*Errore Std.*	*rapporto t*	*p-value*	
const	−0,884907	2,06990	−0,4275	0,6693	
A2	−6,62813	0,919133	−7,211	<0,0001	***
A4	−0,406190	0,0524870	−7,739	<0,0001	***
A11	−0,316996	0,0438246	−7,233	<0,0001	***
A15	0,124765	0,0228123	5,469	<0,0001	***
A17	0,495175	0,0588482	8,414	<0,0001	***
A18	−0,343673	0,0501107	−6,858	<0,0001	***
A19	0,128222	0,0216097	5,934	<0,0001	***
A22	2,96687	0,279541	10,61	<0,0001	***
A23	2,12949	0,109719	19,41	<0,0001	***
A24	−1,45274	0,195193	−7,443	<0,0001	***
A25	0,109497	0,0327538	3,343	0,0009	***
A26	0,172892	0,0376442	4,593	<0,0001	***
A35	0,310804	0,0416312	7,466	<0,0001	***
A37	−0,526936	0,0492388	−10,70	<0,0001	***
A38	0,162683	0,0220756	7,369	<0,0001	***
A43	−0,298970	0,0471779	−6,337	<0,0001	***
A45	0,306284	0,0226383	13,53	<0,0001	***
A52	0,324087	0,0472355	6,861	<0,0001	***
A53	−0,571989	0,0374702	−15,27	<0,0001	***
A56	0,224912	0,0266252	8,447	<0,0001	***

Media var. dipendente	90,83264	SQM var. dipendente	93,71702
Somma quadr. residui	117205,1	E.S. della regressione	18,64912
R-quadro	0,962620	R-quadro corretto	0,960401
F(20, 337)	433,9238	P-value(F)	8,6e-227
Log-verosimiglianza	−1544,595	Criterio di Akaike	3131,191
Criterio di Schwarz	3212,682	Hannan-Quinn	3163,600
rho	0,848673	Durbin-Watson	0,397449



Modello 1080: Effetti fissi, usando 358 osservazioni
Incluse 36 unità cross section
Lunghezza serie storiche: minimo 8, massimo 10
Variabile dipendente: A32

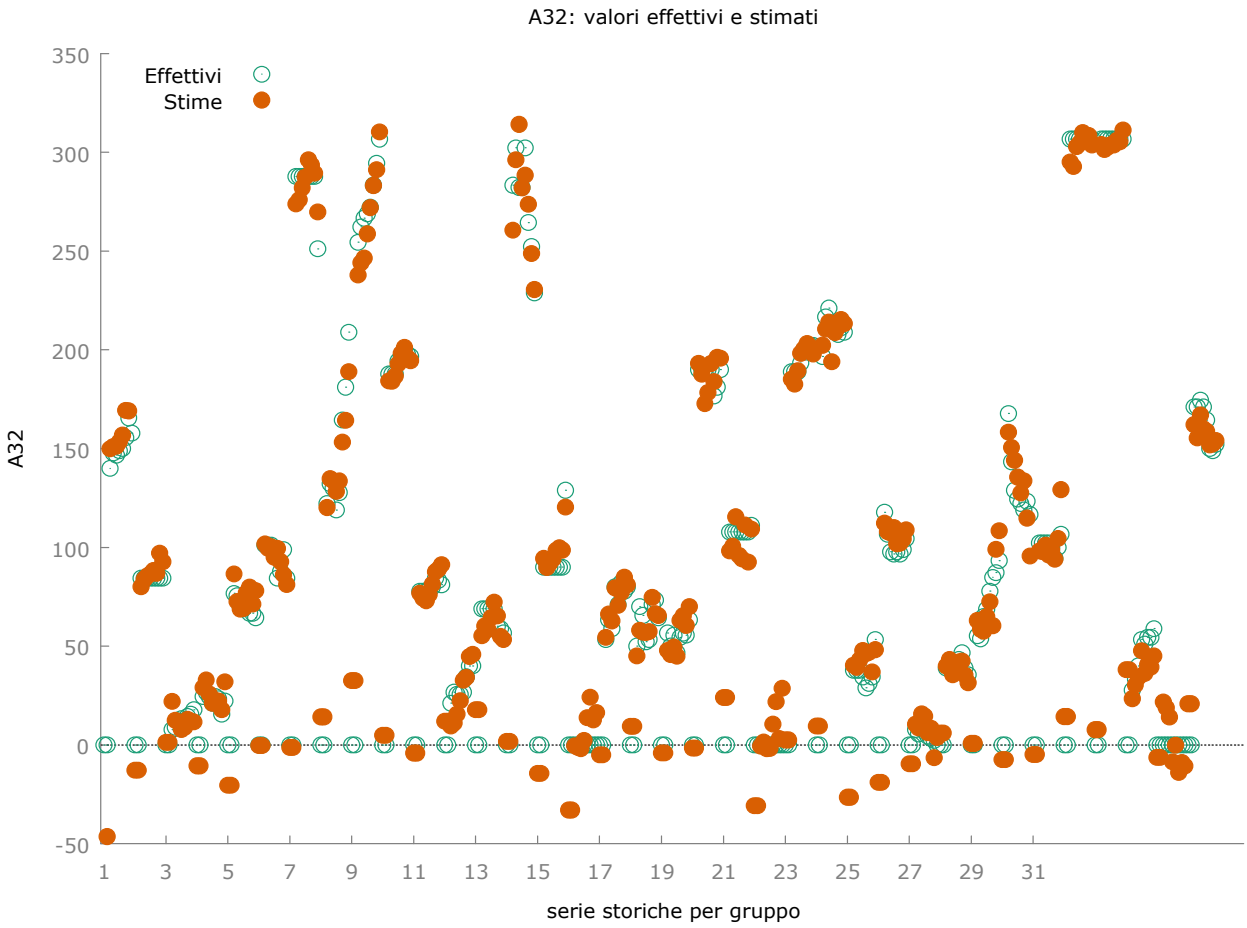
	Coefficiente	*Errore Std.*	*rapporto t*	*p-value*	
const	–0,117227	1,37286	–0,08539	0,9320	
A2	–5,22935	0,657491	–7,953	<0,0001	***
A4	–0,384467	0,0596791	–6,442	<0,0001	***
A11	–0,301216	0,0428192	–7,035	<0,0001	***
A15	0,129128	0,0259806	4,970	<0,0001	***
A17	0,239702	0,0510089	4,699	<0,0001	***
A18	–0,431704	0,0589380	–7,325	<0,0001	***
A19	0,134413	0,0237423	5,661	<0,0001	***
A22	2,36671	0,241144	9,814	<0,0001	***
A23	2,16760	0,113856	19,04	<0,0001	***
A24	–0,970757	0,169764	–5,718	<0,0001	***
A25	0,0605989	0,0284691	2,129	0,0341	**
A26	0,123507	0,0315182	3,919	0,0001	***
A35	0,270102	0,0453225	5,960	<0,0001	***
A37	–0,593602	0,0513089	–11,57	<0,0001	***

A38	0,163784	0,0242166	6,763	<0,0001	***
A43	−0,192830	0,0488521	−3,947	<0,0001	***
A45	0,289750	0,0270400	10,72	<0,0001	***
A52	0,274303	0,0412687	6,647	<0,0001	***
A53	−0,586842	0,0419754	−13,98	<0,0001	***
A56	0,182454	0,0311171	5,863	<0,0001	***

Media var. dipendente	90,83264	SQM var. dipendente	93,71702
Somma quadr. residui	42168,10	E.S. della regressione	11,81649
R-quadro LSDV	0,986551	R-quadro intra-gruppi	0,965654
LSDV F(55, 302)	402,7960	P-value(F)	4,9e-252
Log-verosimiglianza	−1361,611	Criterio di Akaike	2835,221
Criterio di Schwarz	3052,531	Hannan-Quinn	2921,646
rho	0,412893	Durbin-Watson	0,892928

Test congiunto sui regressori -
Statistica test: F(20, 302) = 424,546
con p-value = P(F(20, 302) > 424,546) = 9,10172e-208

Test per la differenza delle intercette di gruppo -
Ipotesi nulla: i gruppi hanno un'intercetta comune
Statistica test: F(35, 302) = 15,3543
con p-value = P(F(35, 302) > 15,3543) = 1,63781e-048



Modello 1081: Effetti casuali (GLS), usando 358 osservazioni
Incluse 36 unità cross section
Lunghezza serie storiche: minimo 8, massimo 10
Variabile dipendente: A32

	Coefficiente	*Errore Std.*	*z*	*p-value*	
const	−0,221777	3,15451	−0,07030	0,9440	
A2	−5,38303	0,644624	−8,351	<0,0001	***
A4	−0,388624	0,0557768	−6,967	<0,0001	***
A11	−0,310829	0,0407813	−7,622	<0,0001	***
A15	0,128288	0,0243327	5,272	<0,0001	***
A17	0,261254	0,0493791	5,291	<0,0001	***
A18	−0,422961	0,0550161	−7,688	<0,0001	***
A19	0,134298	0,0223821	6,000	<0,0001	***
A22	2,43037	0,233912	10,39	<0,0001	***
A23	2,17311	0,107571	20,20	<0,0001	***
A24	−1,01691	0,164290	−6,190	<0,0001	***
A25	0,0647107	0,0275722	2,347	0,0189	**
A26	0,127072	0,0306614	4,144	<0,0001	***
A35	0,277340	0,0427283	6,491	<0,0001	***
A37	−0,589056	0,0485995	−12,12	<0,0001	***

A38	0,163172	0,0228313	7,147	<0,0001	***
A43	−0,204905	0,0463177	−4,424	<0,0001	***
A45	0,291664	0,0251234	11,61	<0,0001	***
A52	0,282972	0,0399089	7,090	<0,0001	***
A53	−0,587529	0,0394327	−14,90	<0,0001	***
A56	0,188598	0,0291416	6,472	<0,0001	***

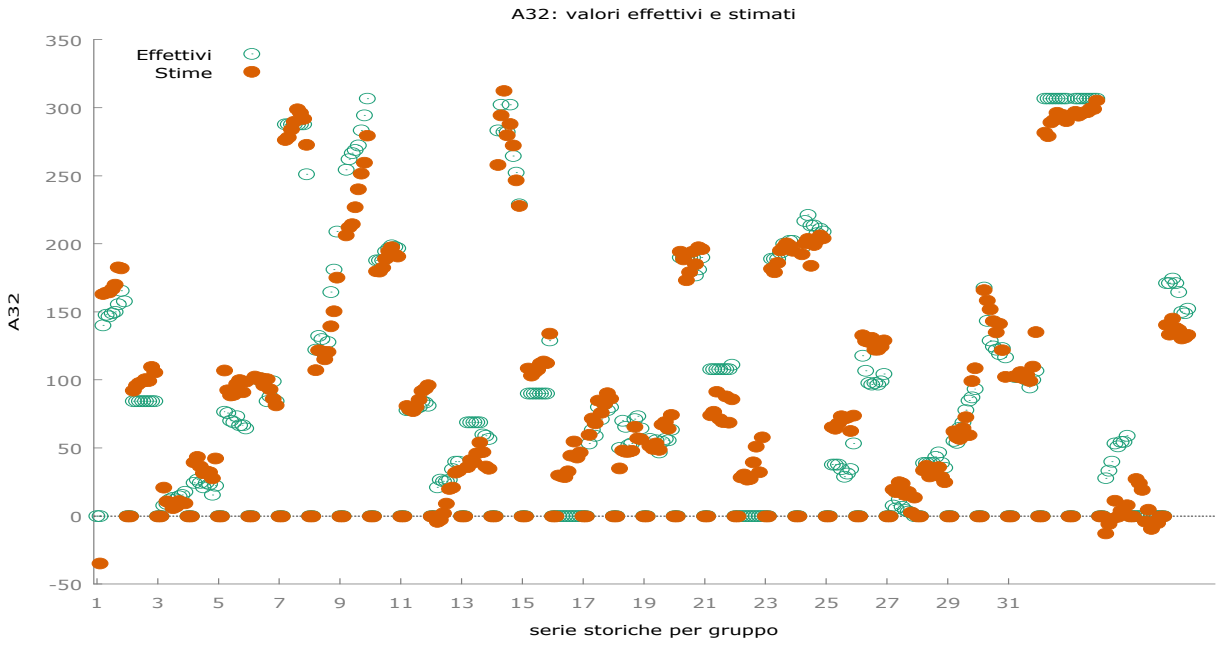
Media var. dipendente	90,83264	SQM var. dipendente	93,71702
Somma quadr. residui	129625,5	E.S. della regressione	19,58335
Log-verosimiglianza	−1562,625	Criterio di Akaike	3167,250
Criterio di Schwarz	3248,741	Hannan-Quinn	3199,659
rho	0,412893	Durbin-Watson	0,892928

Varianza 'between' = 297,461
Varianza 'within' = 139,629
theta medio = 0,787597

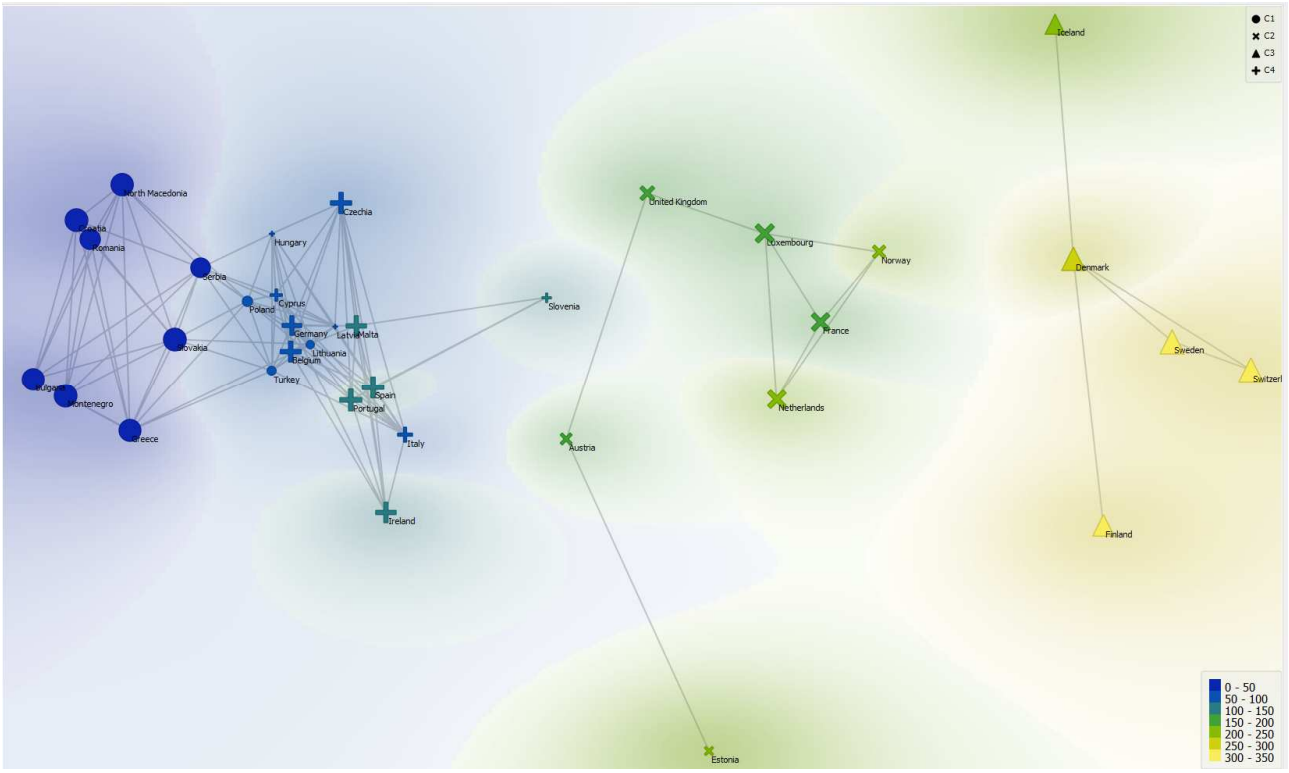
Test congiunto sui regressori -
Statistica test asintotica: Chi-quadro(20) = 9248,3
con p-value = 0

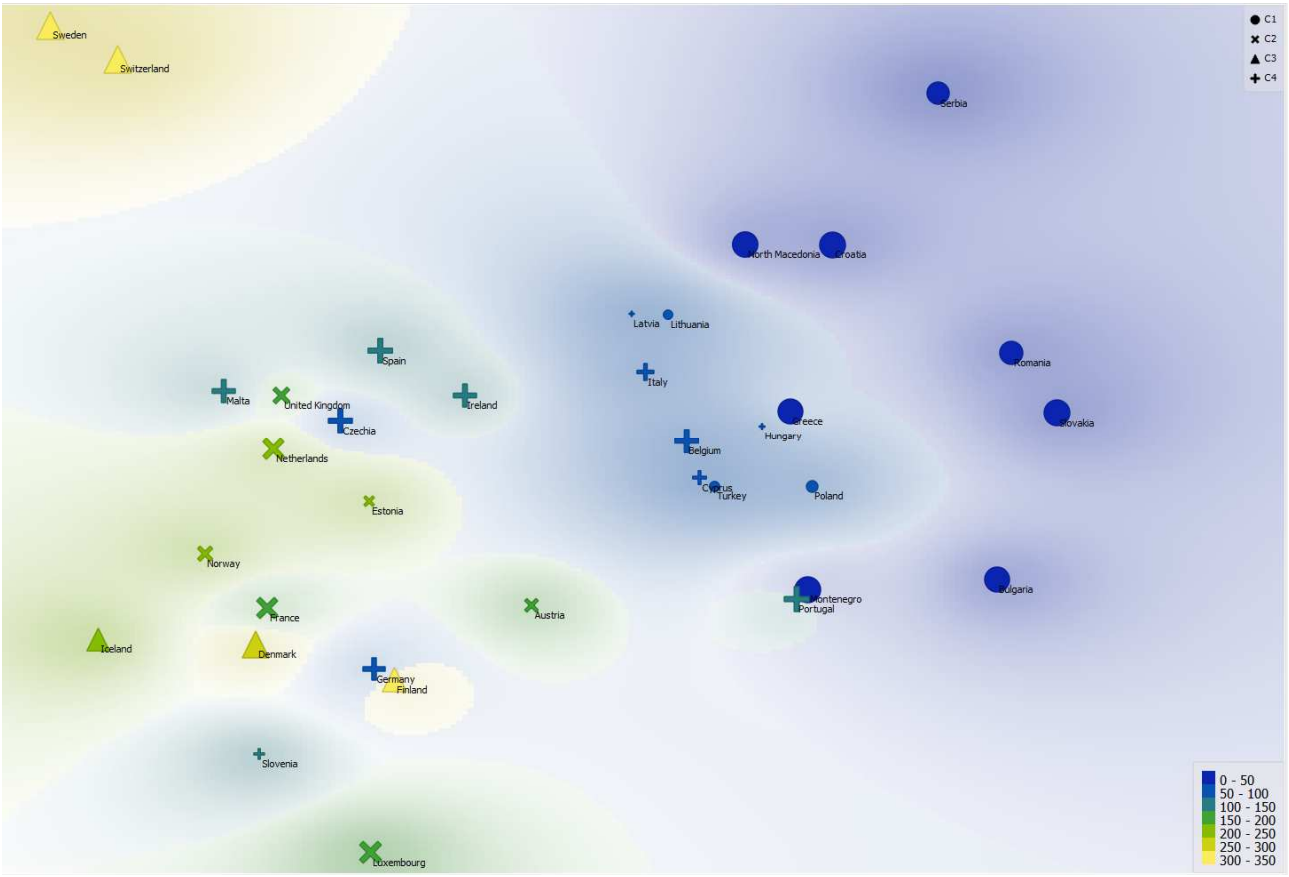
Test Breusch-Pagan -
Ipotesi nulla: varianza dell'errore specifico all'unità = 0
Statistica test asintotica: Chi-quadro(1) = 464,26
con p-value = 5,68787e-103

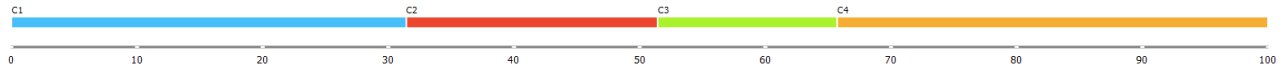
Test di Hausman -
Ipotesi nulla: le stime GLS sono consistenti
Statistica test asintotica: Chi-quadro(20) = 15,4824
con p-value = 0,74817

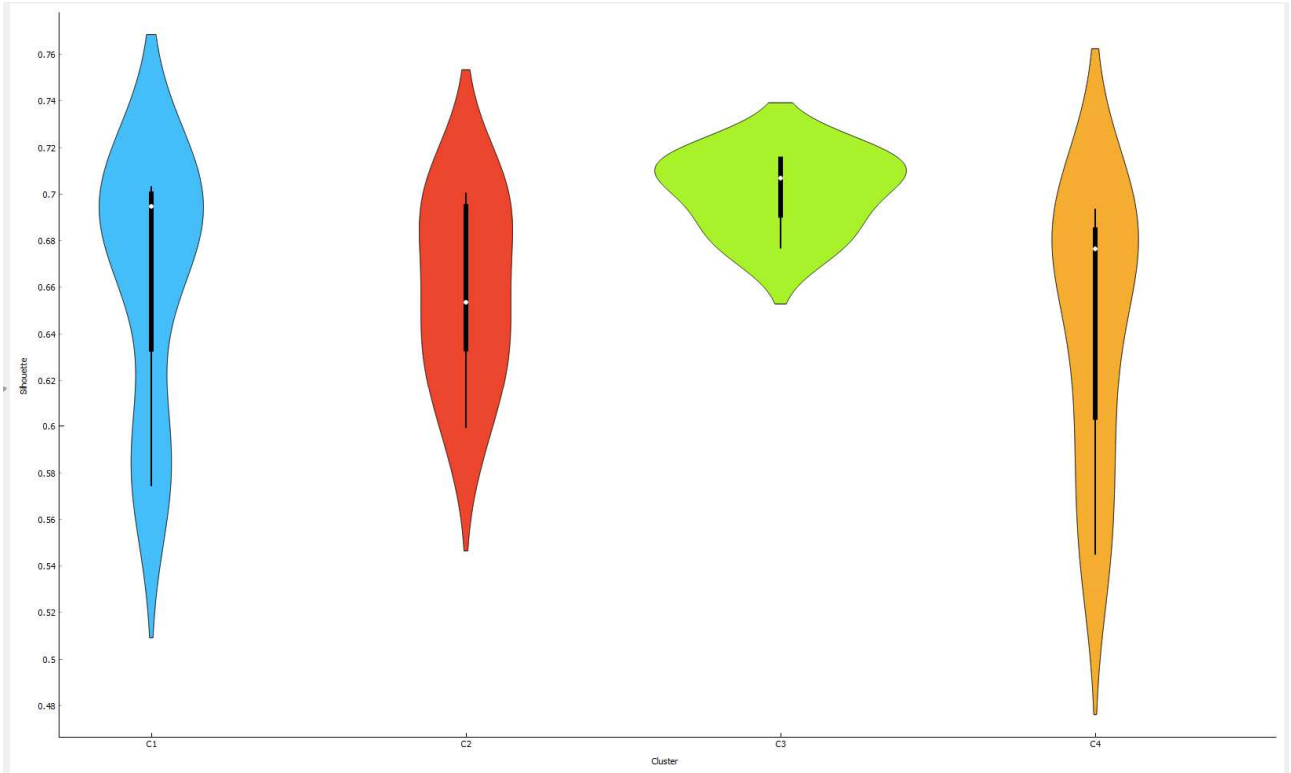


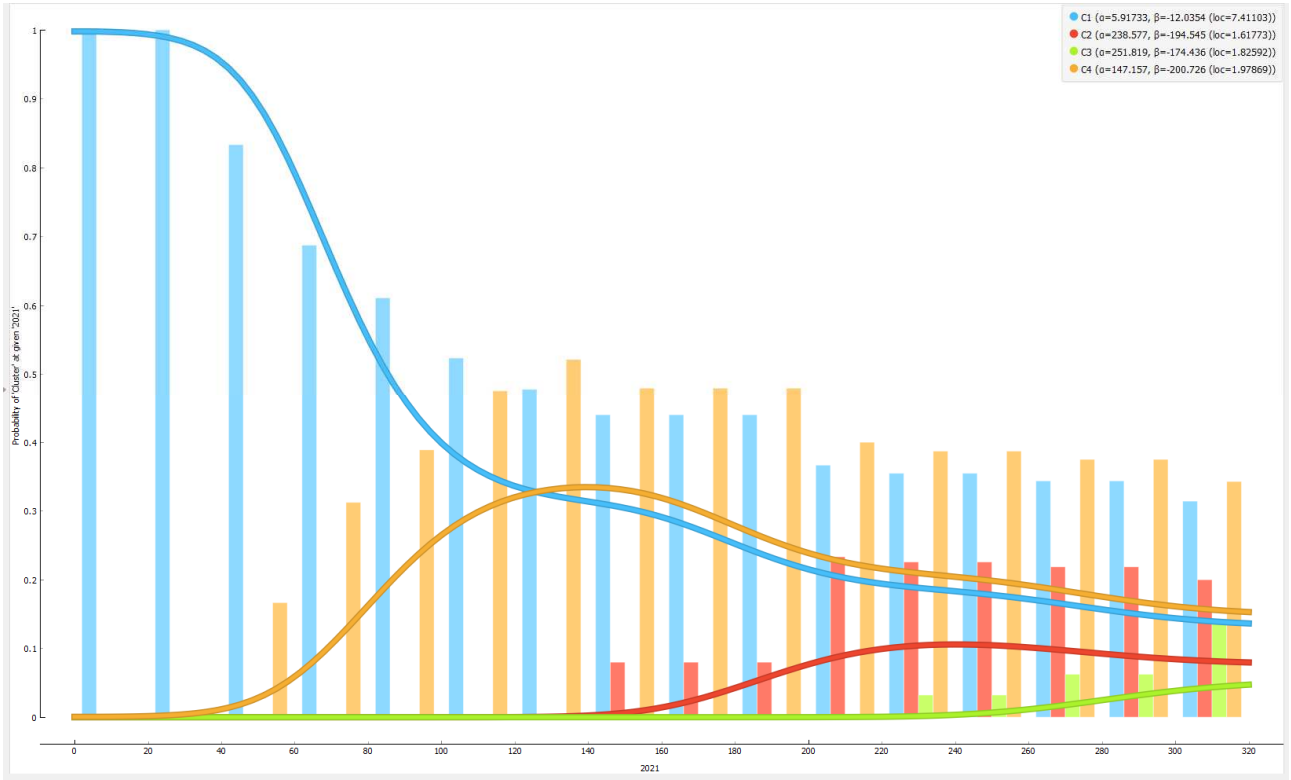
Clusterization

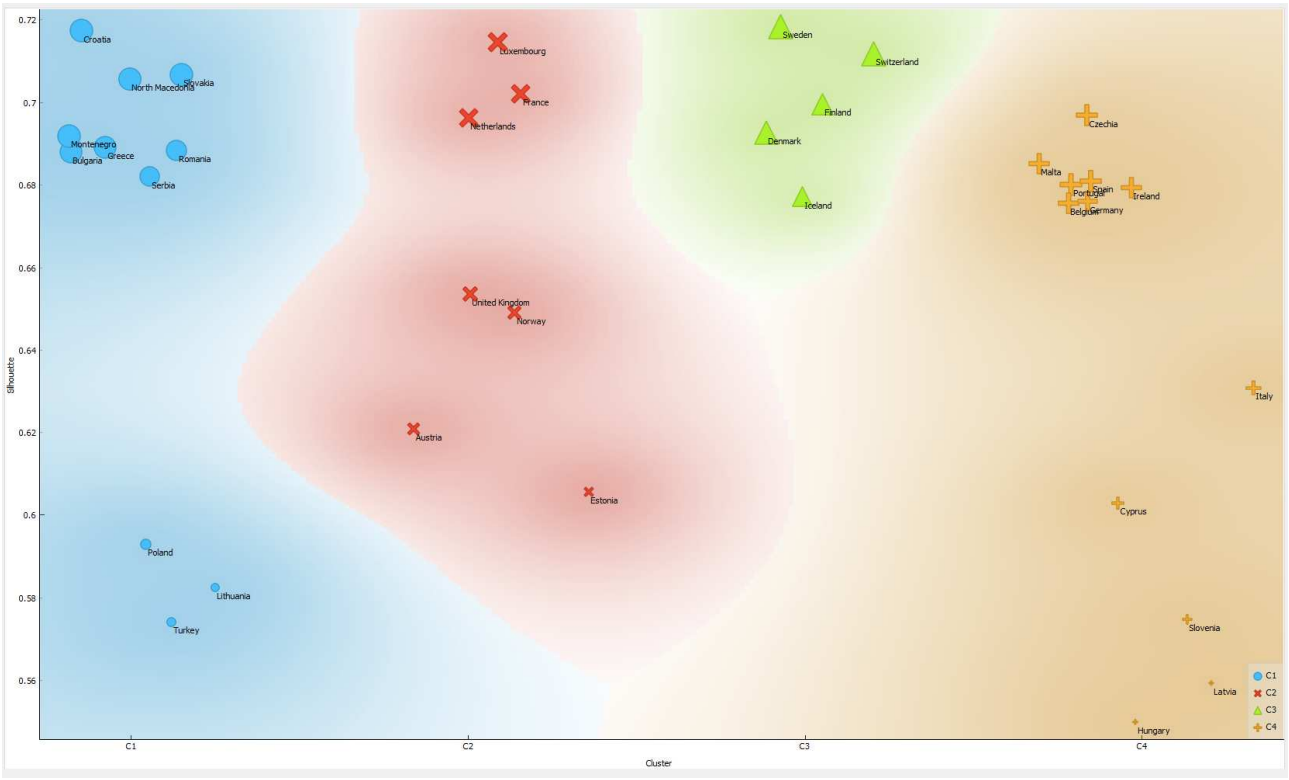


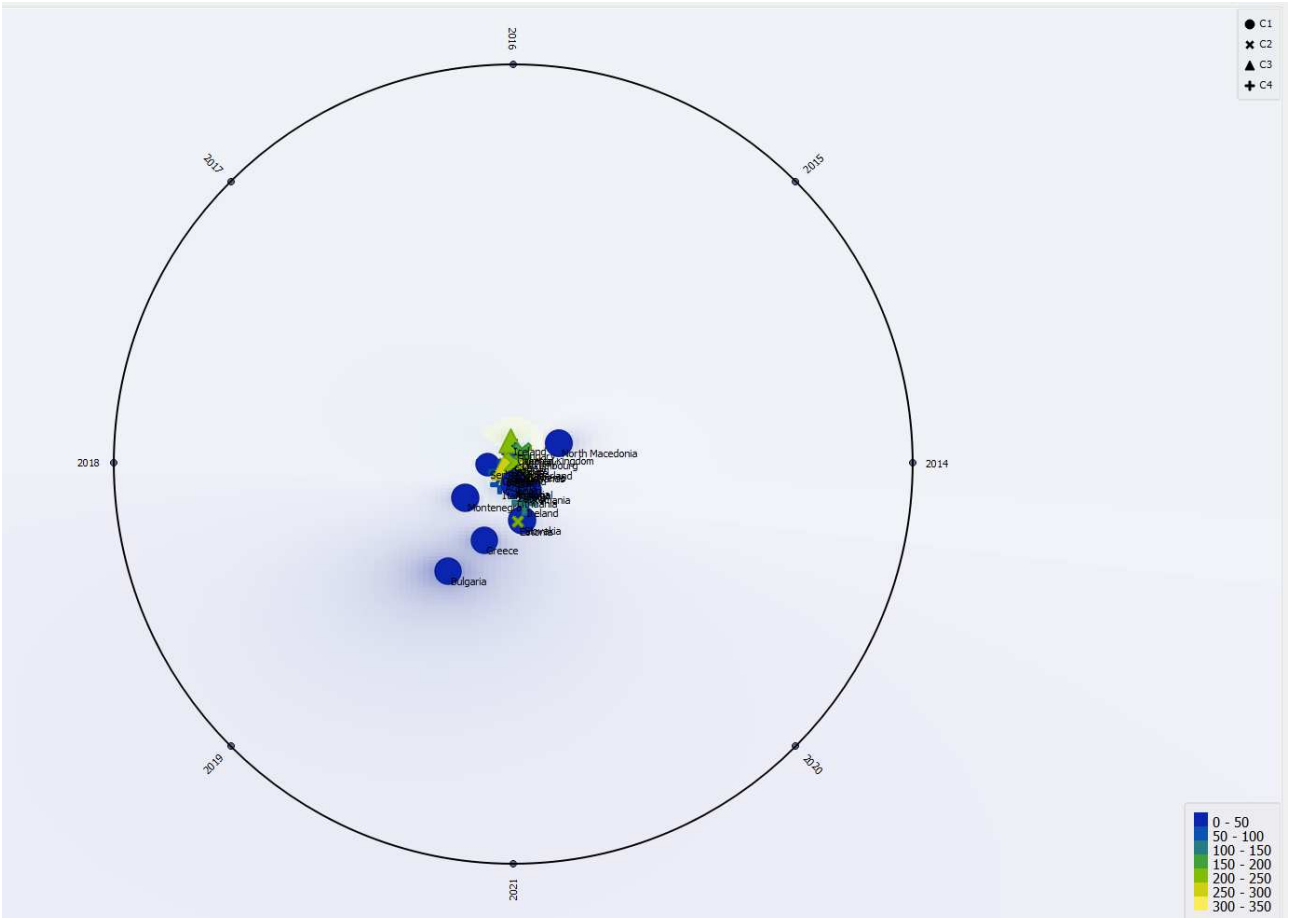


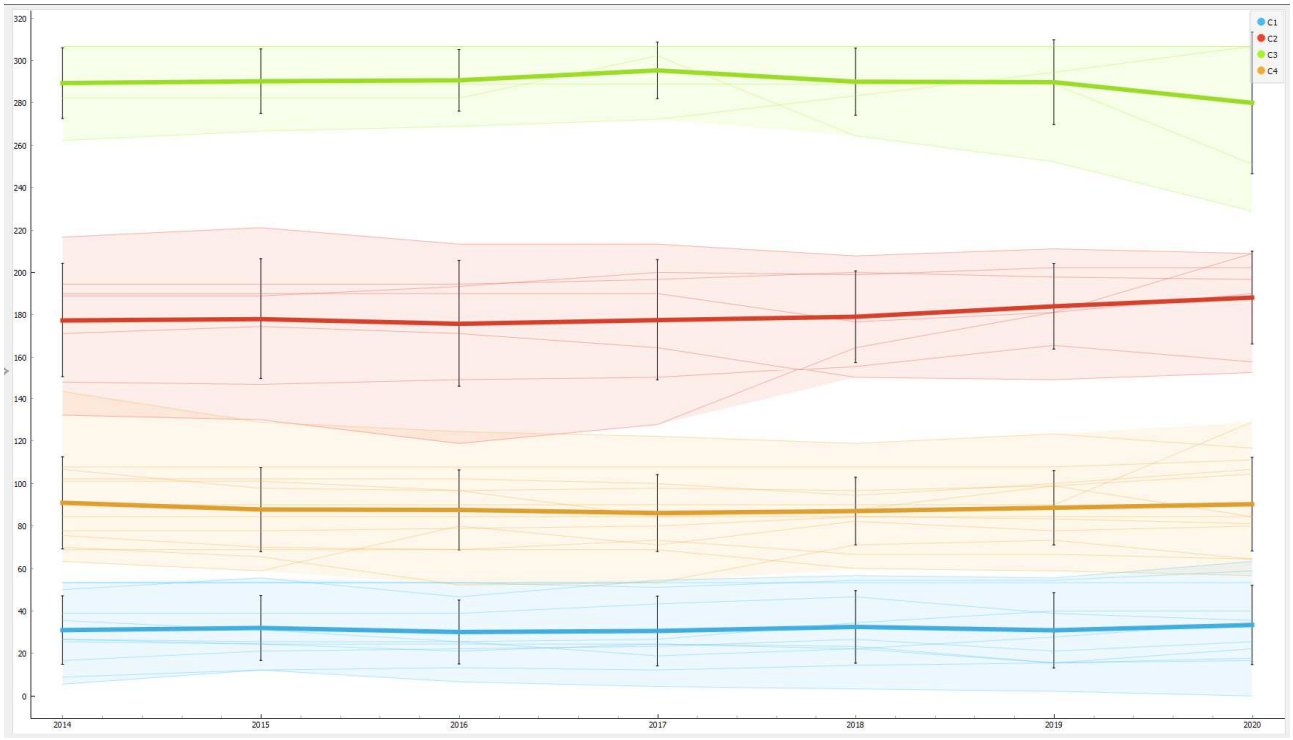

C1
C2
C3
C4
0
10
20
30
40
50
60
70
80
90
100

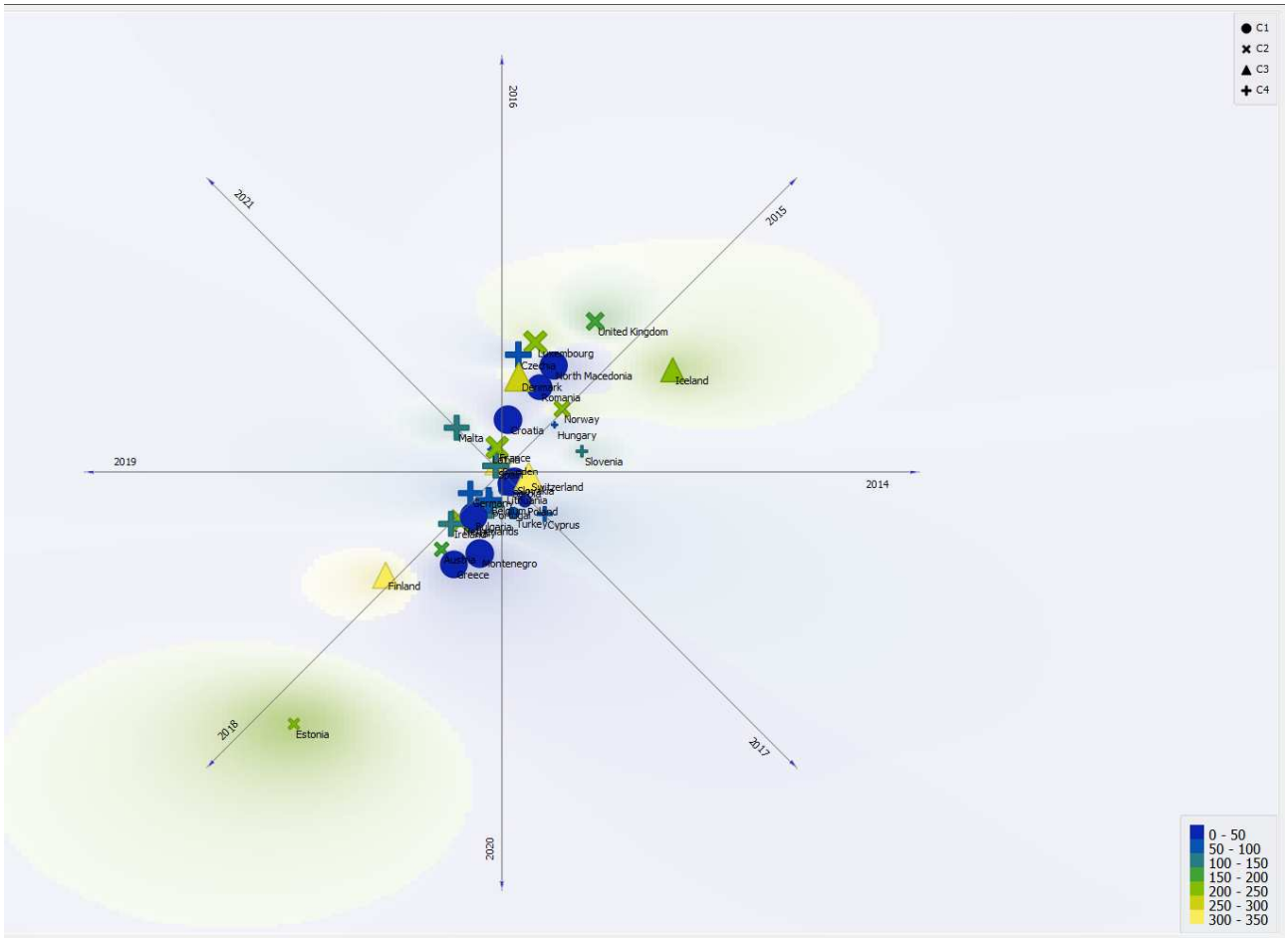

Silhouette
0.76
0.74
0.72
0.7
0.68
0.66
0.64
0.62
0.6
0.58
0.56
0.54
0.52
0.5
0.48
C1
C2
C3
C4
Cluster

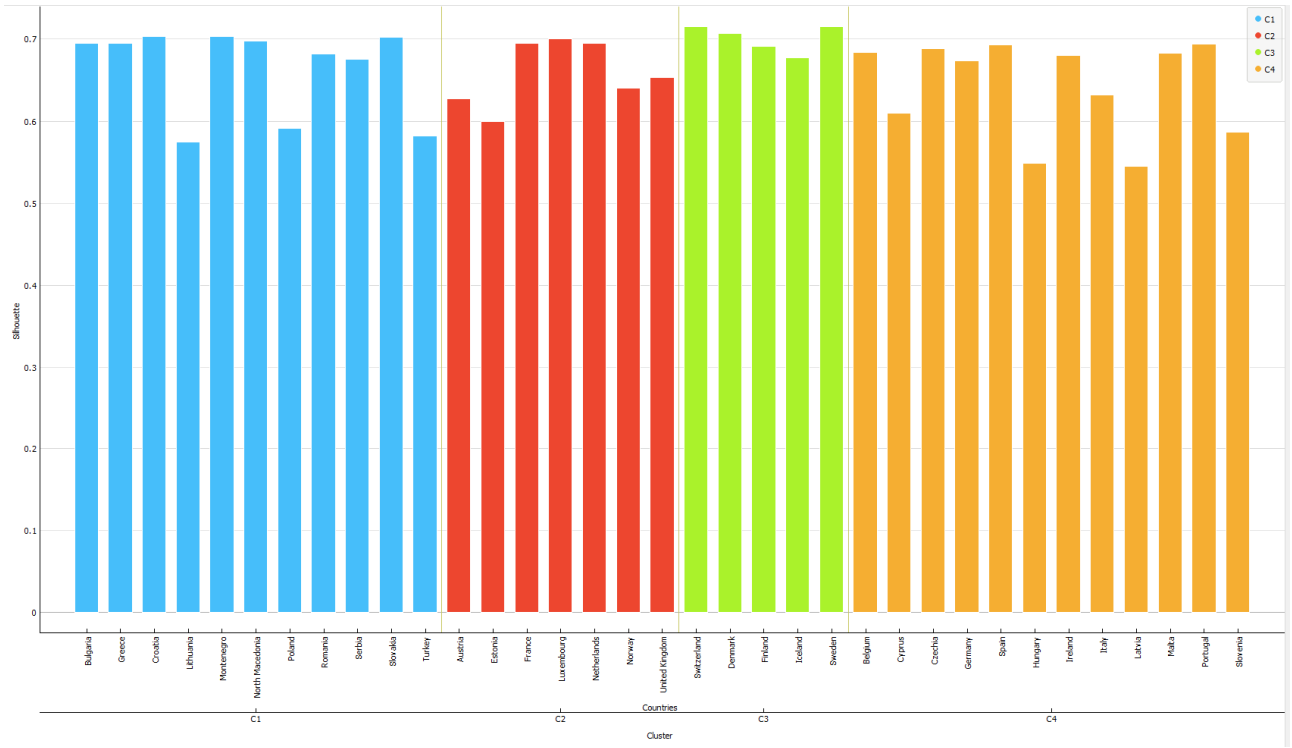

C1 (α=5.91733, β=-12.0354 (loc=7.41103))
C2 (α=238.577, β=-194.545 (loc=1.61773))
C3 (α=251.819, β=-174.436 (loc=1.82592))
C4 (α=147.157, β=-200.726 (loc=1.97869))
Probability of 'Cluster' at given '2021'
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
2021

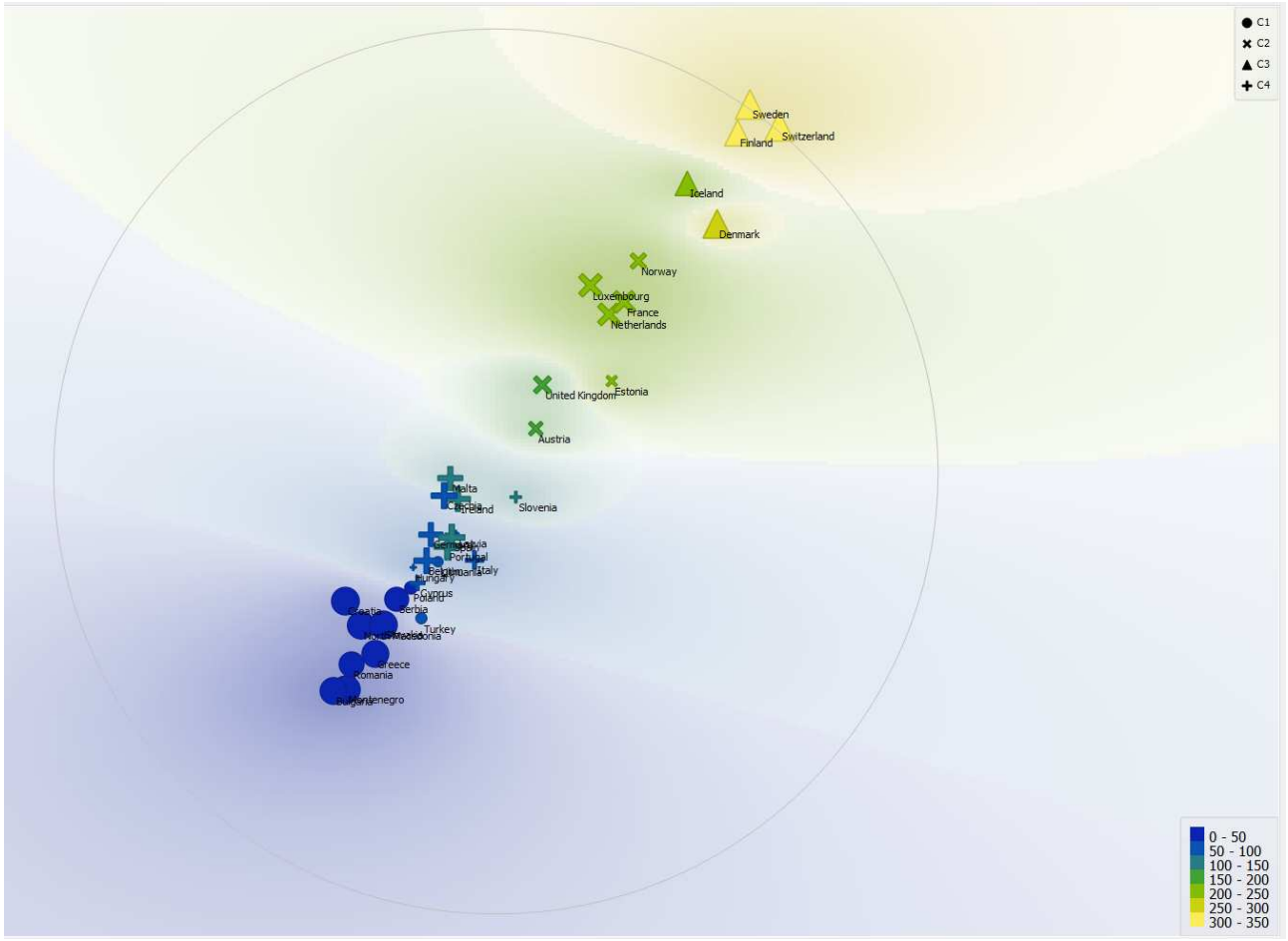

Silhouette
Cluster
C1
C2
C3
C4
Croatia
Slovakia
North Macedonia
Montenegro
Bulgaria
Greece
Romania
Serbia
Luxembourg
France
Netherlands
United Kingdom
Norway
Austria
Estonia
Poland
Lithuania
Turkey
Sweden
Switzerland
Finland
Denmark
Iceland
Czechia
Malta
Portugal
Spain
Ireland
Belgium
Germany
Italy
Cyprus
Slovenia
Latvia
Hungary


2016
2015
2014
2021
2020
2019
2018
2017
C1
C2
C3
C4
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350

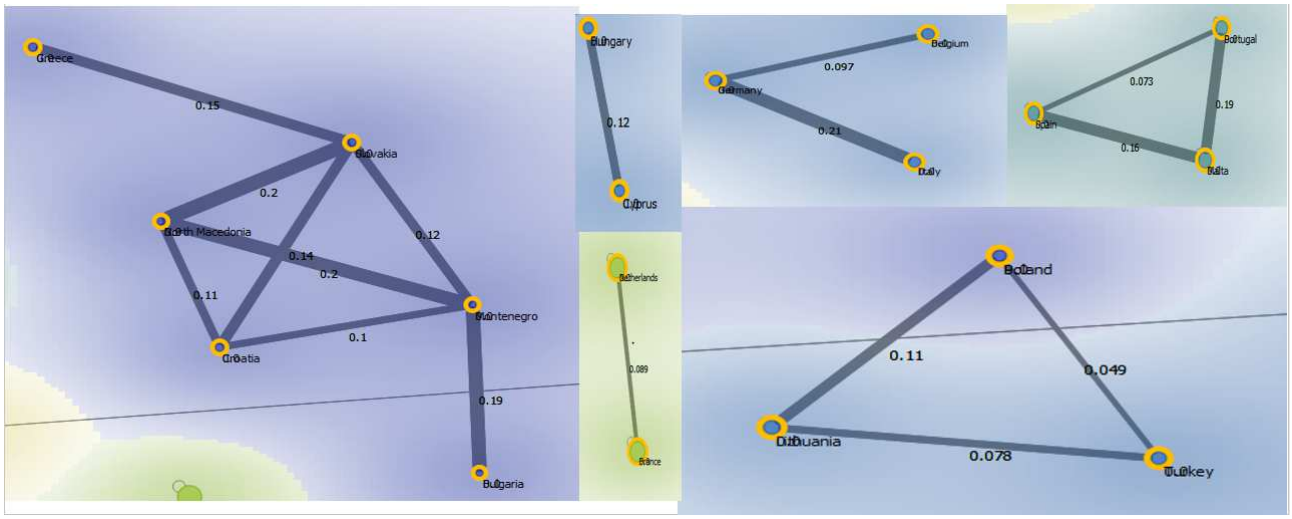

C1
C2
C3
C4
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
2014
2015
2016
2017
2018
2019
2020


C1
C2
C3
C4
2016
2021
2015
2019
2014
2018
2017
2020
United Kingdom
Luxembourg
Czechia
North Macedonia
Iceland
Denmark
Romania
Norway
Malta
Croatia
Hungary
Slovenia
Switzerland
Poland
Turkey
Cyprus
Montenegro
Greece
Finland
Estonia
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350



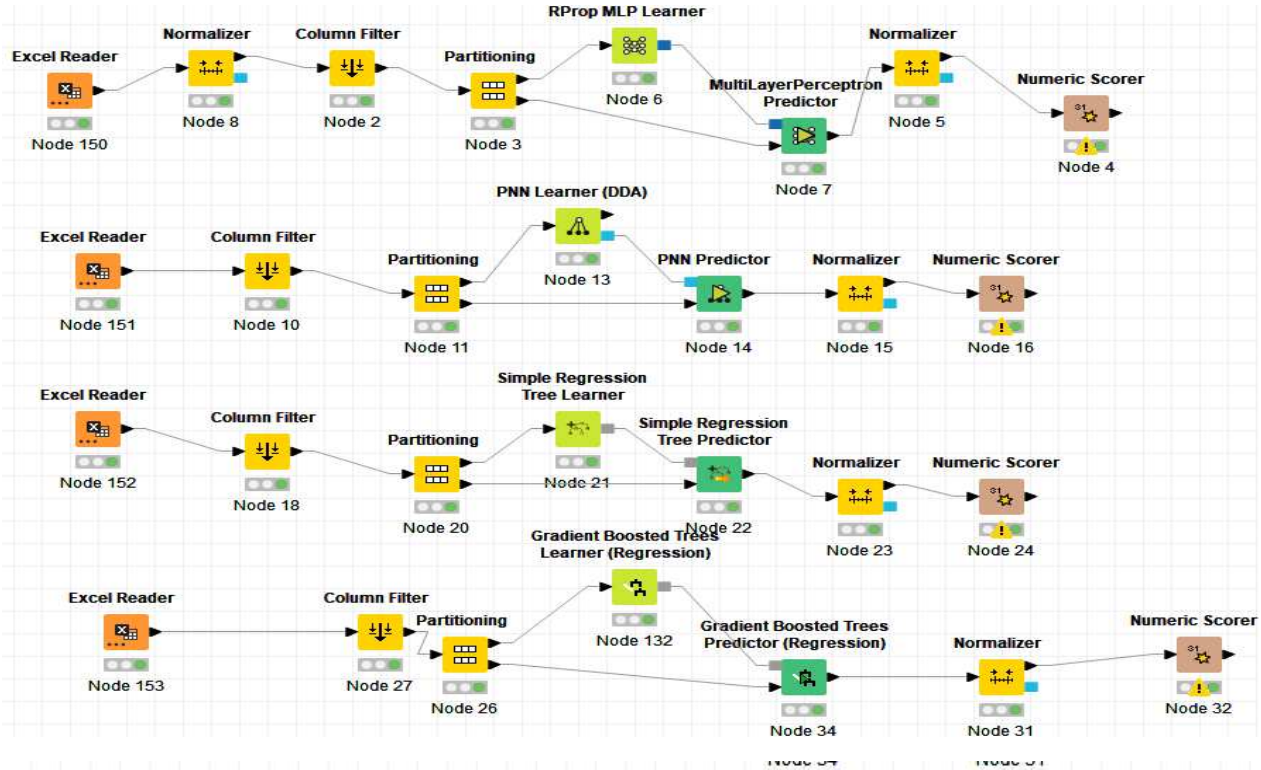


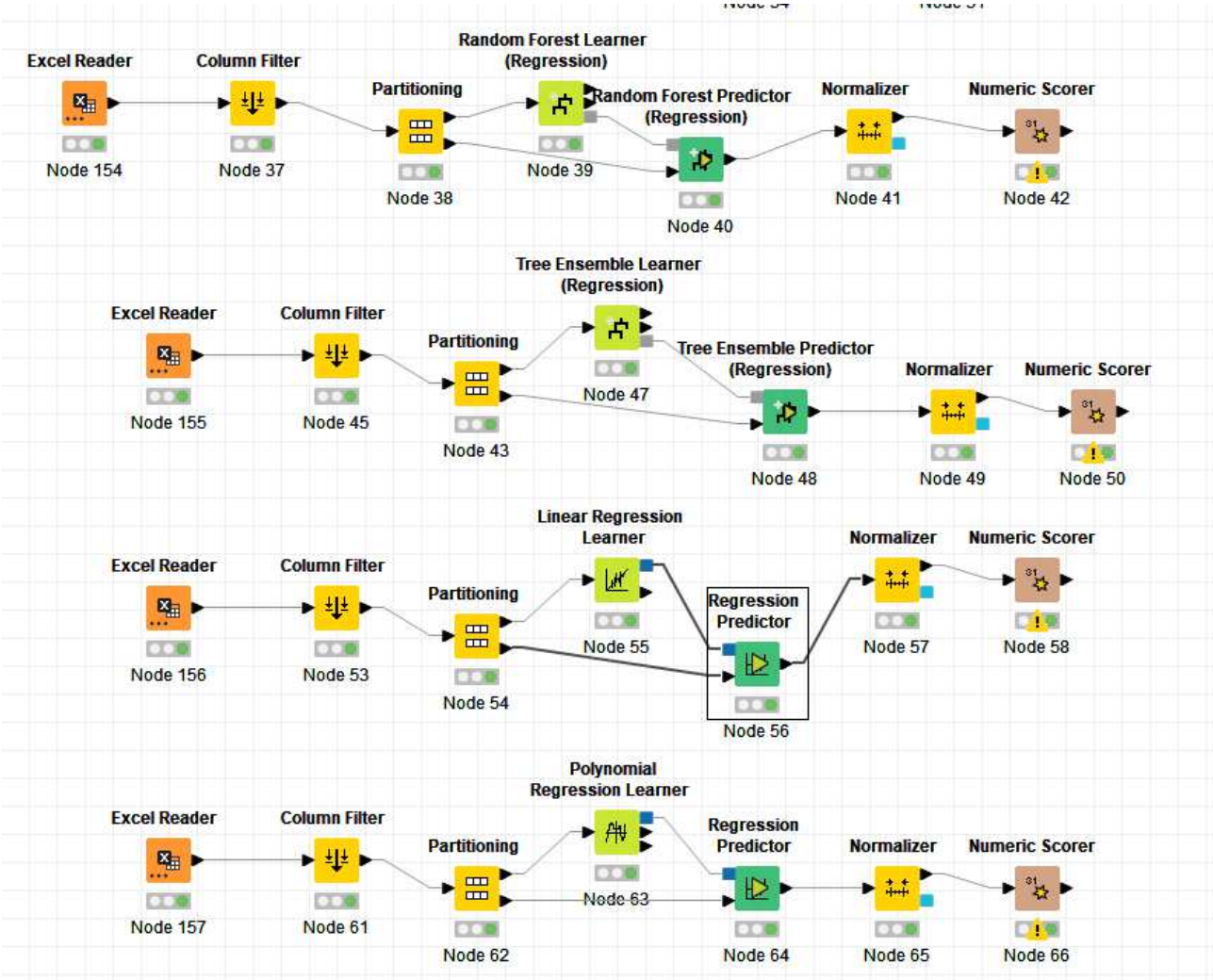
Network Analysis



Statistical Results of Machine Learning Algorithms				
	ANN	*PNN*	*Simple Regression Tree*	*Gradient Boosted Trees Learner*
R^2	0,844491410	0,982566447	0,969303855	0,923752741
Mean absolute error	0,097877646	0,030594794	0,052740427	0,064858533
Mean squared error	0,015510759	0,001708686	0,004955870	0,011396215
Root mean squared error	0,124542199	0,041336259	0,070397943	0,106753058
	Random Forest Regression	*Tree Ensemble*	*Linear Regression*	*Polynomial Regression*
R^2	0,895540577	0,980104815	0,997628039	0,976449952
Mean absolute error	0,060092493	0,024679254	0,014038691	0,028968173
Mean squared error	0,007332816	0,001615010	0,000000000	0,002954123
Root mean squared error	0,085631860	0,040187186	0,017401115	0,054351847

Ranking of Algorithms for Predictive Performance					
	R^2	**Mean absolute error**	**Mean squared error**	**Root mean squared error**	**Sum**
Linear Regression	1	1	1	1	4
Tree Ensemble	3	2	2	2	9
PNN	2	4	3	3	12
Polynomial Regression	4	3	4	4	15
Simple Regression Tree	5	5	5	5	20
Random Forest Regression	7	6	6	6	25
Gradient Boosted Trees Learner	6	7	7	7	27
ANN	8	8	8	8	32


RProp MLP Learner
Excel Reader
Normalizer
Column Filter
Partitioning
MultiLayerPerceptron Predictor
Normalizer
Numeric Scorer
Node 150
Node 8
Node 2
Node 3
Node 6
Node 7
Node 5
Node 4
PNN Learner (DDA)
Excel Reader
Column Filter
Partitioning
PNN Predictor
Normalizer
Numeric Scorer
Node 151
Node 10
Node 11
Node 13
Node 14
Node 15
Node 16
Simple Regression Tree Learner
Excel Reader
Column Filter
Partitioning
Simple Regression Tree Predictor
Normalizer
Numeric Scorer
Node 152
Node 18
Node 20
Node 21
Node 22
Node 23
Node 24
Gradient Boosted Trees Learner (Regression)
Excel Reader
Column Filter
Partitioning
Gradient Boosted Trees Predictor (Regression)
Normalizer
Numeric Scorer
Node 153
Node 27
Node 26
Node 132
Node 34
Node 31
Node 32


Random Forest Learner (Regression)
Excel Reader
Column Filter
Partitioning
Random Forest Predictor (Regression)
Normalizer
Numeric Scorer
Node 154
Node 37
Node 38
Node 39
Node 40
Node 41
Node 42
Tree Ensemble Learner (Regression)
Excel Reader
Column Filter
Partitioning
Tree Ensemble Predictor (Regression)
Normalizer
Numeric Scorer
Node 155
Node 45
Node 43
Node 47
Node 48
Node 49
Node 50
Linear Regression Learner
Excel Reader
Column Filter
Partitioning
Regression Predictor
Normalizer
Numeric Scorer
Node 156
Node 53
Node 54
Node 55
Node 56
Node 57
Node 58
Polynomial Regression Learner
Excel Reader
Column Filter
Partitioning
Regression Predictor
Normalizer
Numeric Scorer
Node 157
Node 61
Node 62
Node 63
Node 64
Node 65
Node 66