The Export of Medium and High-Tech Products Manufactured in Europe

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Abstract:

In this article we analyze the determinants and the export trend of European countries of medium and high technology products. The data were analyzed using various econometric models, namely WLS, Pooled OLS, Dynamic Panel, Panel Data with Fixed Effects, Panel Data with Random Effects. The results show that exports of medium and high-tech products are positively associated, among other variables, with the value of "Average Annual GDP Growth", "Total Entrepreneurial Activity" and "Sales Impacts", and negatively associated with, among other variables, "Human Resources", "Government and Procurement of Advanced Technology Products" and "Buyer Sophistication".

A cluster analysis was realized with the *k*-Means algorithm optimized with the Silhouette coefficient. The result showed the presence of only two clusters. Since this result was considered poorly representative of the industrial complexity of the European Union countries, a further analysis was carried out with the Elbow method. The result showed the presence of 6 clusters with the dominance of Germany and the economies connected to the German economy. In addition, a network analysis was carried out using the distance to Manhattan. Four complex network structures and two simplified network structures were detected. A comparison was then made between 10 machine learning algorithms for predicting the value of exports of medium and high-tech products. The result shows that the best performing algorithm is the SGD. An analysis with Augmented Data-AD was implemented with a comparison between 10 machine learning algorithms for prediction and the result shows that the Linear Regression algorithm is the best predictor. The prediction with the Augmented Data-AD allows to reduce the MAE by about 0.0022131 compared to the prediction with the Original Data-OD.

Keywords: innovation; invention; incentives; technological management innovation; R&D; open innovation.

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

Introduction

The following article deals with the issue of exports of high-tech products. The data used refer to the European Commission's European Innovation Scoreboard-EIS database which includes 36 countries in the period 2010-2019. The analysis of exports of medium and high technology products to Europe is a central theme both for the economic development of Eastern European countries and for ensuring that the European Union continues to be an internationally competitive area. The current global scenario in fact puts at risk both the condition of the Eastern European countries and the role of the European Union in globalization. In fact, if on the one hand the countries of Eastern Europe are increasingly threatened by Russian expansionism following the Russian invasion of Ukraine, on the other hand the European Union is behind both the USA and China, in technological innovations.

Furthermore, it must be considered that the adverse conditions generated by the Covid 19 pandemic, galloping inflation, the rise in the prices of raw materials and the increase in public debt of many Western countries, makes it very difficult for European countries to continue to support the technological innovation and research and development. The climate issue is also aggravating the overall picture, which prevents many countries from investing in the knowledge economy as they need to direct resources towards the energy transition and the development of environmentally sustainable energies.

To these phenomena must then be added more technical issues that refer to the tensions in international trade between China, Europe, Russia, and the USA that also involve other relevant countries such as Turkey, Brazil, South Africa, and India. In fact, the choice by the US to return to producing high-tech products on US soil could create friction at an international level and reduce trade. Above all, the crisis between the US and China on the Taiwan issue could have negative effects on international trade, even in highly technological products, which generally pass-through China and Taiwan.

The result is a very uncertain international economic policy condition for the trade, even of highly technological products. And therefore, although it is clear both in the data and in the theoretical literature, that exports of high-tech products are an essential element for promoting economic growth in terms of Gross Domestic Product, a condition has arisen that could limit the international trade in high-tech products, aggravating economic conditions and creating the conditions for a long recession. Globalization, which until a few years ago seemed a certainty, is now being questioned. And even the economies that produce high-tech products could have difficulties in exporting not because their products are not sufficiently advanced or in demand, but on the contrary, because the political condition could limit international trade.

Therefore, precisely because data and economic theory are in agreement in emphasizing the role of exports of high-tech products in promoting economic growth and employment, it is necessary that international institutions be active and vigilant in preventing the current global economic situation it is oriented towards cold war scenarios or towards real armed conflicts that are absolutely contrary to the path of growth and progress that globalization has guaranteed both to the West and to the East.

The article continues as follows: the second paragraph contains the analysis of the literature, the third paragraph refers to the econometric model, the fourth paragraph presents clustering, the fifth paragraph refers to network analysis, the sixth paragraph shows the results of the prediction with the use of machine learning with original data, the seventh paragraph refers to prediction with the use of machine learning and augmented data, the eighth paragraph concludes. The appendix details the statistical results obtained through economic, clustering and machine learning techniques.

1. Literature Review

Below is a summary of an analysis of the literature concerning the macroeconomic impact of exports of medium and high technology products.

Lomachynska, et al. (2020) analyze the impact of Foreign Direct Investments in promoting exports to the countries of the Visegrad group, namely Poland, the Czech Republic, Slovakia, and Hungary. The authors verify the existence of a positive relationship between foreign direct investments and the value of exports, with a significant growth of medium and high technology products. However, the data show that despite the growth in exports of medium and high-tech products, the level of technological innovation of the countries of the Visegrad group remains low compared to the European average values.

Śledziewska and Akhvlediani (2017) compare the characteristics of the EU-15 countries with those of the countries of the Visegrad-V4 group with reference to the determinants of the export of medium and high technology products. The authors use a gravitational model. The results show that while human capital is significantly associated with the growth of the exposure of medium and high technology products in the EU-15 countries, this relationship is not present in the V4 countries.

Juchniewicz and Łada (2020) underline the role of technological innovation and research and development in the growth of the competitiveness of European countries with positive effects in terms of export of technological products. Demir (2018) analyzes the impact of exports of low-, medium- and high-tech products on economic growth for 34 countries between 1995 and 2015. The authors verify that the export of high-tech products has a positive impact in terms of economic growth. The export of medium technology products has a moderate impact on economic growth. The export of low-tech products has a negative impact in terms of economic growth.

Sahin (2019) highlights the presence of a cause-effect relationship between the export orientation of technologically advanced products and the economic growth of Turkey's GDP through the Granger Causality analysis.

Erkişi and Boğa (2019) calculate the impact of exports of medium and high technology products in promoting the economic growth of the European countries of the EU15 in the period between 1998-2017. The results show that there is a positive relationship between the export of high-tech products and economic growth. The authors estimate that 1% growth in exports of medium and high-tech products generates GDP growth of 0.49% in the short term. In the long run, the 1% growth in exports of medium and high technology products generates a GDP growth of 0.34%. Finally, the authors verify that the growth of high-tech exports has an impact not only on economic growth, but also on fixed capital formation and employment.

Kabaklarli, et al. (2017) analyze the role of technological innovation in promoting exports of high-tech products considering the OECD countries in the period between 1987 and 2015. The authors verify that direct foreign investments and the production of intangible goods have a very positive impact in terms of high-tech export growth. However, the authors point out that GDP growth does not necessarily steer the economy towards exports of medium- and high-tech products. Policy considerations arise: if countries want to grow, they must invest in technological innovation, attract foreign capital, and invest in patents and intellectual capital protection. Kabaklarlý, et al., (2018) consider the role of exports of high-tech products as a factor for the growth of gross domestic product in the period between 1989 and 2015 in a select group of 14 OECD countries. Meral (2019) verifies that the export of high-tech products has a positive impact in terms of gross domestic product. However, to ensure that there is a growth in exports of high-tech products, it is necessary to invest in intellectual capital and attract foreign direct investments. The author checks for a positive relationship between investment in research and development and a country's ability to increase GDP through exports of advanced technology products. Based on this analysis, the author suggests to the Turkish government to invest further in research and development and to create the conditions for a growth in exports of high-tech products to stimulate GDP growth.

Domazet, et al. (2022) investigate the relationship between export of high-tech products and economic growth measured in terms of GDP in the following countries, namely: Serbia, Hungary, Romania, and Bulgaria. The authors use Eurostat data over the period 2008-2018. The results show that exports of highly technological products have a positive impact on GDP only in the case of Bulgaria. The positive relationship between exports of technological products and GDP growth is instead absent in Serbia, Hungary, and Romania. The authors conclude by stressing that investment in innovation must not be aimed exclusively at exports but rather must concern a broader strategy that can guide the country to the application of the knowledge economy.

Usman (2017) analyzes the relationship between exports of high-tech products and the growth of gross domestic product in Pakistan. The author uses data from World Bank and national statistical sources in the period between 1994 and 2014. The policy conclusions are clear: although Pakistan is not an advanced industrialized economy and still has an important agricultural component, it is essential that investments are made to grow exports of high-tech products. Ekananda and Parlinggoman (2017) consider the positive impact that the export of technology-intensive products has in promoting the productivity of the most innovative sectors. Xi and Ming (2020) analyze the case of exports of high-tech products considering the city of Shenzen in China. The authors consider the connection between the export of high-tech products, scientific and technological investments, and the competitiveness of the city of Shenzen both in the Chinese and international context.

Using a composite dataset made up of both developing and developed countries in the period 1996-2012, Bayraktutan and Bıdırdı (2018) try to estimate the impact of patents in promoting exports of high-tech products with attention also to the consequences in terms of GDP. Exports of high-tech products are defined as consisting of three factors: patents, fixed assets, and Foreign Direct Investment (FDI). The results show that the rise in patents generates a positive impact in terms of exporting high-tech products to both developing and developed countries. However, in the short term, the elements that have the greatest impact on the growth of exports of highly technological products are fixed assets and Foreign Direct Investments. Enjolras, *et al.* (2019) analyze the relationship between technological innovation, productivity, competitiveness, and export orientation in French small and medium-sized enterprises. The data shows that small and medium-sized enterprises with high-tech products are not the ones that export the most. On the other hand, the small firms that export the most produce low-tech products.

Pan, et al. (2022) analyze the relationship between the presence of industrial agglomerations and the export of high-tech products manufactured in China using a comprehensive data panel for the period 2010-2016. The authors verify the presence of a positive relationship between industrial agglomerations and the ability to create increasingly competitive and innovative high-tech products for export. The results also show the presence of a role of educational structures at the regional level in supporting the exports of highly technological products through investment in human capital. The telecommunications sector and the sale of equipment for industry are the sectors in which industrial agglomerations are most efficient in the sense of exports of high-tech products.

2. Econometric Model for the Estimation of the Export of Medium and High-Tech Products

The determinants of the export of medium and high technology products manufactured in Europe are investigated below. The variable is analyzed in the context of the European Innovation Scoreboard (EIS) database of the European Union. The data refer to 36 countries between 2010 and 2019. The export of medium and high technology products is an indicator that highlights the ability of European Union companies to maximize the results of investments in research and development through exports. An important role is also recognized in technological innovation as a driver for the development of products aimed at export. In general, the ability of a country to export

medium and high-tech products also reflects the competitiveness of companies and the ability to exploit the intangible assets produced by the research and innovation system. Furthermore, the fact that a country can export medium and high-tech products is also an important indicator of its ability to promote economic growth with a positive impact on employment as well. In fact, generally the countries that export medium and high-tech products also have a qualified and well-paid human capital. An econometric analysis was carried out below to estimate the value of exports of medium and high technology products manufactured in Europe. The data were analyzed through a set of econometric techniques, namely: Panel Data with Fixed Effects, Panel Data with Random Effects, Pooled OLS, WLS. The data show that the export of medium and high technology products is positively associated with the following variables, namely:

- *Average annual GDP growth;* it is a variable that considers the growth rate of the Gross Domestic Product on average. There is a positive relationship between the value of exports of medium and high-tech products and the trend in gross domestic product. This relationship appears to be in line with the classic approach which tends to highlight the efficiency and productivity of economies that are positively oriented towards exports, especially the export of technologically advanced products. Obviously, the benefits of international trade derive from this in terms of enriching the countries, increasing the income in the exporting country. Exports can be a significant force capable of driving gross domestic product towards economic growth with the possibility of positively stimulating the industrial and production system to seek innovative solutions based on technology and human capital.
- *Total Entrepreneurial Activity;* it is a variable that considers the percentage of the population aged between 18 and 64 who is a nascent entrepreneur or owner of a business. There is therefore a positive relationship between the growth of the population of entrepreneurs at a national level and the value of exports of medium and high technology products manufactured in Europe. This relationship can be better investigated as a sociological phenomenon considering that if a country has a very strong orientation towards the export of advanced technological products, then most likely it also has companies that are more productive and competitive. Therefore, the diffusion of successful business models can push people to activate emulation behaviors such as to generate a growth of entrepreneurship at a national level with the spread of new businesses.
- *Sales impacts;* is a variable made up of three sub-variables namely: Exports of medium and high technology products, Exports of knowledge-intensive services, Sales of new-to-market and new-to-firm product innovations. There is therefore a positive relationship between the export of medium and high technology products and the value of the impact of technological innovation on sales. This relationship is only partly tautological and means that effectively if a country can make products that contain technological innovations and research and development products, then the probability of exports is also higher. In fact, we remind you that there is a significant positive relationship between the ability to innovate, the ability to do research and development, and the production capacity and ability of the company to export. Therefore, if a country innovates significantly then the chances of increasing productivity and exports also increase (Costantiello, *et al.* 2021).
- *Employment Share High and Medium high-tech manufacturing;* it is a variable that considers the employment generated by medium and high technology products on the total general employment. For medium and high technology products, activities in the sector of pharmaceutical products, computers, chemicals, weapons and ammunition, machinery and equipment, motor vehicles, ship and boat construction, tools and domestic supplies are considered. There is therefore a relationship between the employment generated by medium and high technology products and the exports of medium and high technology products. Obviously the two activities are closely connected. The greater the ability of companies to produce medium and high-tech products, the greater the ability of companies to export and vice versa, i.e., companies that export more could also have greater opportunities to hire staff thanks to the growth in productivity and turnover.
- *Innovation index;* is an overall indicator of a country's ability to innovate from a technological point of view. This indicator is extremely synthetic and refers to a set of characteristics of the economy considered. The determination of the innovation index includes both institutional and entrepreneurial elements relating to human capital, and to the dimension of research and development funding from both a public and private point of view (Leogrande, *et al.* 2020). There is therefore a positive relationship between the value of the innovation index and the value of exports of medium and high technology products. This relationship is since the growth in the degree of technological innovation at the country level also increases productivity and directs companies to export (Leogrande, *et al.* 2022).

- *Foreign-controlled enterprises - share of value added;* is a measure that takes into consideration the added value of foreign-controlled companies at the cost of factors in millions of euros. By foreign-controlled companies we mean companies for which the controlling office is located abroad with respect to the size of the operational headquarters. There is a positive relationship between the added value produced by foreign-controlled companies and exports of medium and high-tech products. Countries that tend to export medium and high-tech products are also countries for which there is greater investment by foreign companies. In this regard, it is possible that these are either very competitive countries with high value-added companies that attract investors for profit or countries where the cost of labor is low and therefore become the destination of relocation.
- *Firm investments;* is a variable made up of a group of sub-variables, that is: R&D expenditure in the business sector, Non-R & D innovation expenditures, Enterprises providing training to develop or upgrade ICT skills of their personnel. In other words, these are variables that highlight the ability to invest in research and development spending at the business level, in the formation of human capital and in that innovation that is not derives from research and which is mainly attributable to the expertise acquired in the market. It follows therefore that the countries in which there is funding for research and development are also able to carry out productive investments at an industrial level that lead competitive companies to export internationally. This relationship stems from the fact that national systems that better finance research and technological innovation also have greater opportunities to develop an industrial economic system that is more competitive in terms of productivity and exports (Costantiello, et al. 2021).
- *Population size;* is a variable that considers the average population at the country level. There is therefore a positive relationship between the value of the population from a demographic point of view and the value of exports of medium and high technology products manufactured in Europe. This relationship can be considered as connected to the fact that the large European countries in terms of population*, i.e.,* Germany, France and the United Kingdom, are among the most industrialized and have very high export levels. This is certainly not the case in Italy, Spain and Poland, which together make up about 140 million inhabitants and which, however, have lower levels of industrialization compared to the leading European countries. It follows that effectively the ability to manufacture and export medium and high technology products tends to grow with the increase of the population even if this proposition is not true for all countries. In fact, there are countries of considerable size that appear to be behind in the export of medium and high technology products. However, economic convergence within the European Union is likely to lead to an increase in the average level of exports for all EU countries.
- *New doctorate graduates;* is the number of research doctorates per 1,000 inhabitants as a percentage of the total number of graduates. There is therefore a positive relationship between the number of PhDs and the value of exports of medium and high technology products. This relationship can be better understood considering that to generate medium and high technology products it is necessary to make a significant investment in human capital. In fact, the human capital formed above all with tertiary education can generate value by ensuring that technological innovations can become medium and high technology products to be sold abroad. For this reason, countries that have advanced industrial systems invest heavily in the training of PhDs. In addition, industrialization and export-oriented countries also have programs that connect companies to universities and research centers to raise the technological level of products and generate growth in terms of tech exports.
- *Top R&D spending enterprises for 10 million population:* is a variable that considers the expenditure on research and development by the best 2,500 companies. There is a positive relationship between the value of research and development expenditure by large and very large companies and the value of exports of medium and high technology products. This relationship can be better understood considering that it is precisely large and very large companies that through investment in research and development are able to export medium and high technology products. In fact, SMEs or medium-sized companies do not have the ability to create research and development departments that can create real innovations in technologies and products of research and development. Instead, large, and very large companies can hire the best researchers and scientists to invest effectively in the creation of new products for export. Furthermore, the level of know-how of large and very large companies is such as to allow them to identify long-term paths in the evolutionary and innovative development of technological products to be exported.
- *Rule of law:* is a variable that takes into account the trust that people have in the fact that the rules of society are respected. Rule of law also notes in the sense of having certainties about the possibility of executing contracts, that there is also a recognition of intellectual property rights, and that there are also

police systems and a judicial system that can effectively prosecute crimes and violence. There is therefore a positive relationship between the value of the rule of law and the value of exports of medium and high technology products manufactured in Europe. In fact, at the European level, in countries where there is greater respect for the law and greater effectiveness of the legal system, there is also a greater probability of doing international trade, attracting foreign investors, and orienting virtuous companies to export. In fact, in these countries there is also trust in foreign counterparties, that if the contracts were not respected, it would be possible to appeal to the judiciary, obtaining the repayment of the advances or the termination of the contract.

- *Lifelong learning:* is a variable that considers the percentage of the European population participating in forms of lifelong learning. Data relating to lifelong learning are collected through the EU Labor Force Survey. By permanent learning we mean all those learning activities that are aimed at the acquisition of new knowledge, the growth of individual skills and professional skills. However, sporting, and cultural activities are not included in lifelong learning. Therefore, for example, practicing a sport or playing the guitar are not considered as activities falling within lifelong learning. There is a positive relationship between lifelong learning and exports of medium and high technology products. This relationship means that in the countries that export the most, there is also a greater overall orientation towards investment in capital within a large breast, which is precisely captured by the lifelong learning variable (Costantiello, *et al.* 2022).
- *Basic-school entrepreneurial education and training;* It is a variable that considers the presence of entrepreneurship education present in the basic school system of the countries. As is evident from the analysis, it appears that the value of exports of medium and high technology products tends to be positively associated with the value of entrepreneurship education present at school level. This relationship can be better understood considering that if countries can export medium and high technology products, this possibility is also associated with the presence of widespread entrepreneurship at the country level, which also finds its strength in training. scholastic. Furthermore, countries that can export high and medium technology products are aware of the advantages of entrepreneurship and may be much more likely to create pedagogical paths aimed at developing business and management skills.
- *Tertiary education;* is the number of people with post-secondary education in the 25-34 age group. In the analysis of these variables, not only science and technology are taken into consideration, but also other skills which, especially in the service sector, can generate forms of technological innovation. This variable is also able to capture the variations in university-level educational policies. There is a positive relationship between the value of tertiary education and the value of exports of medium and high technology products. This relationship can be better understood considering that the economies that are able to export the most are also those that have the most trained human capital or that have a larger number of people with tertiary education. In fact, tertiary education includes scientists, engineers and high-level professionals of the STEM disciplines who are essential to ensure that companies can invest in the creation of new medium and high technology products.
- *Trademark applications:* is an indicator that considers the number of trademark recognition applications that are filed both with the Intellectual Property Office of the European Union and at the World Intellectual Property Office. Brands are important indicators of technological innovation especially in the advanced tertiary sector. The essential functions of the brand are three: clearly identify the goods and services that are produced and sold by the company, guarantee quality towards the consumer, effectively convey advertising to the public of current and potential buyers. There is a positive relationship between the value of trademark applications and exports of medium and high technology products manufactured in Europe. This positive relationship can be understood considering that generally the companies that export also invest heavily in marketing, on the brand, on packaging, or on all those elements of product and company recognition, which are connected to the brand, which allow to develop market relations with foreign customers (Costantiello, et al. 2021).
- *SMEs innovating in-house:* is a variable that considers small and medium-sized enterprises that carry out technological innovation activities internally. These are companies that have introduced product or process innovations alone or in collaboration with other companies and organizations. This number is considered as a percentage of the total value of the total small and medium-sized enterprises. This indicator therefore represents the ability of small and medium-sized enterprises to innovate independently by creating new products and services. The indicator takes into consideration only small and medium-sized enterprises since in general medium-large enterprises have internal structures capable of generating new products and services. While small and medium-sized enterprises that

innovate autonomously are rarer than medium-large enterprises that innovate autonomously. By small and medium-sized enterprises we mean companies that have employees between 10 and 249. There is therefore a positive relationship between countries that export medium and high-tech products and the presence of small and medium-sized enterprises that innovate independently. This positive relationship can be better understood considering that in countries where there is a general export orientation, even innovative small and medium-sized enterprises are able to export (Leogrande, et al. 2022).

- *Employment fast-growing enterprises of innovative sectors:* is the number of employees in the most innovative companies operating in the following sectors, namely: extraction of oil and natural gas, extraction of minerals, manufacturing and technologically advanced services. This value is taken as a percentage of total employment in companies with more than 10 employees. This indicator offers information on the growth rate of companies that grow rapidly in the most innovative sectors. It is therefore a model that captures the ability of companies to invest effectively by seizing the widest opportunities offered by the growing demand for tech goods and services. There is a positive relationship between the value of employment in the most innovative companies and the value of exports of medium and high technology products. Obviously the most innovative companies, which are growing more, also have more employees and are essentially export-oriented. Therefore innovativeness, employment, productivity, competitiveness, and export are related factors (Costantiello and Leogrande 2021).
- *Foreign doctorate students:* is the percentage of foreign doctorates out of the total number of doctorates. The presence of foreign doctorates is an indicator capable of representing the international mobility of students. Countries most oriented towards technological innovation and research and development tend to attract PhD students from abroad to be competitive in the production of science, patents, and intangible capital. There is a positive relationship between the value of the presence of foreign doctorates and exports of medium and high technology products. This relationship can best be understood considering that countries that invest heavily in research and development tend to invest in very innovative PhD scholarships and scientific research programs. For this reason, they attract researchers from abroad and highly competitive from the scientific point of view and the production of goods and intangible assets. The presence of a positive relationship between human resources and exports of medium and high technology products is therefore confirmed, at least with reference to the presence of foreign doctorates (Laureti, et al. 2022)

Table 1. Estimation of the export value of medium and high technology products manufactured in Europe

VARIABLE		Dynamic Panel	POOLED OLS	FIXED EFFECTS	RANDOM EFFECTS	WLS	Average
Medium and high-tech product exports	A35	Coefficient-P Value	Coefficient-P Value	Coefficient-P Value	Coefficient-P Value	Coefficient-P Value	
Constant		1,35068**	1,395	1,36934	1,42161	0,962629	1,299852
Average annual GDP growth	A2	3,01442***	7,33008***	5,2903***	5,61322***	7,34252***	5,718108
Basic-school entrepreneurial education and training	A4	0,24863***	0,0909555**	0,12961**	0,13209***	0,089332***	0,138124
Buyer sophistication	A6	-6,95691***	-10,932***	-7,643***	-8,1906***	-9,94986***	-8,734468
Employment fast-growing enterprises of innovative sectors	A9	0,082186**	0,107419***	0,11316***	0,11337***	0,119666***	0,10716
Enterprises providing ICT training	A15	-0,112211***	-0,103676***	-0,1134***	-0,1132***	-0,097858***	-0,108073
Finance and support	A17	-0,120444**	-0,128591***	-0,1198***	-0,1243***	-0,121525***	-0,122942
Firm investments	A18	0,3615***	0,323226***	0,42239***	0,40837***	0,320232***	0,367144
Foreign doctorate students	A19	0,065042**	0,11671***	0,08284***	0,08925***	0,119105***	0,094588
Foreign-controlled enterprises – share of value added	A20	0,434316***	0,375898***	0,51199***	0,49503***	0,398253***	0,443099
Government procurement of advanced technology products	A22	-0,812556***	-0,846729***	-1,1546***	-1,1543***	-0,793964***	-0,952418
Human resources	A23	-0,701316***	-0,623248***	-0,8415***	-0,8307***	-0,608293***	-0,721021
Innovation index	A24	0,4033**	0,50687***	0,57213***	0,59286***	0,475413***	0,510113
Innovative sales share	A26	-0,171991***	-0,138898***	-0,1528***	-0,1501***	-0,141516***	-0,151048
Innovators	A28	-0,143353**	-0,193149***	-0,1435***	-0,153***	-0,186191***	-0,163841
Knowledge-intensive services exports	A31	-0,32033***	-0,319431***	-0,2439***	-0,2611***	-0,358538***	-0,300672
Lifelong learning	A32	0,147051**	0,130245***	0,16979***	0,16679***	0,114818***	0,145737
Most-cited publications	A36	-0,13942**	-0,251513***	-0,201***	-0,2127***	-0,21553***	-0,204021
New doctorate graduates	A37	0,208984***	0,150848***	0,22369***	0,21844***	0,152546***	0,190902
Non-R&D innovation expenditure	A38	-0,107323***	-0,0499934***	-0,0968***	-0,0904***	-0,038209***	-0,076541
Population size	A42	0,192011*	0,343722***	0,25925***	0,27256***	0,424389***	0,298388
Rule of law	A48	0,402102***	0,0962158*	0,15905**	0,1503**	0,051444	0,171823
Sales impacts	A49	1,07428***	1,09268***	0,91502***	0,93723***	1,07143***	1,018128
Share High and Medium high-tech manufacturing	A50	0,723568***	1,24945***	0,86092***	0,9164***	1,19459***	0,988985
Share Knowledge-intensive services (%)	A51	-0,59857***	-0,735636***	-0,6555***	-0,6673***	-0,926954***	-0,716792
SMEs innovating in-house	A52	0,118575**	0,163709***	0,08293*	0,09197**	0,168464***	0,125128
Tertiary education	A53	0,162316**	0,0829144***	0,17103***	0,16133***	0,093273***	0,134171
Top R&D spending enterprises per 10 mln population	A54	0,156056***	0,199045***	0,14929***	0,15757***	0,22823***	0,178038
Total Entrepreneurial Activity (TEA)	A55	0,98307***	1,47166***	1,51976***	1,55964***	1,44714***	1,396254
Trademark applications	A56	0,143517***	0,114299***	0,13149***	0,12726***	0,114174***	0,126148
Turnover share SMEs	A58	-0,193158***	-0,418554***	-0,3255***	-0,3409***	-0,427851***	-0,341181

Furthermore, the results show that the export of medium and high technology products manufactured in Europe is negatively associated with the following variables, namely:

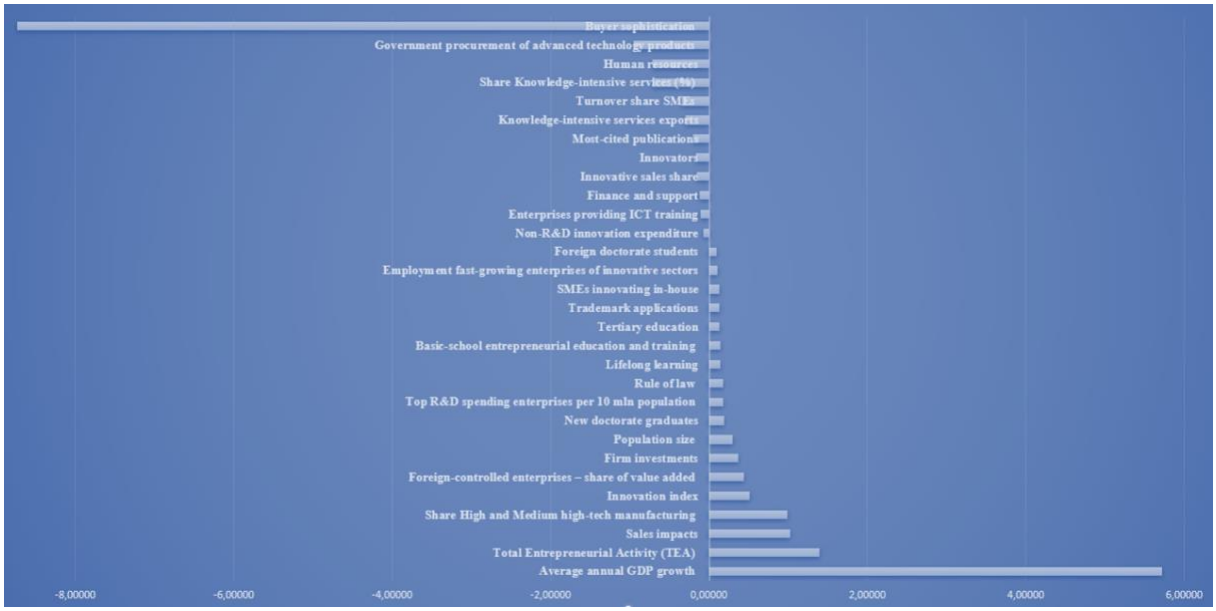
- *Non-R & D innovation expenditure:* is a variable that takes into consideration the sum of the total expenditure for innovation without considering the expenditure on research and development as a percentage of the total turnover of companies. It is therefore an indicator that considers expenditure on technological innovation net of research and development. These items can include, for example, the resources necessary for investments in plant and machinery, intellectual property rights, which are necessary for the diffusion of new technologies. There is therefore a negative relationship between the value of innovation expenditure net of research and development and the value of exports of medium and high technology products. It follows that only countries that invest in technological innovation as a product of research and development have the possibility of generating those products and services that can be successfully exported abroad. In fact, technological innovation related to research and development tends to be deeper and has the possibility of creating products that can be more attractive to foreign markets.
- *Enterprises providing ICT training:* is a variable that considers the number of companies that have invested in the professional training of their employees in the Information Communication Technology sector as a percentage of the total value of the companies considered. There is a negative relationship between the percentage value of firms investing in employee training and the value of exports of medium and high technology products. This relationship indicates that for companies to be able to produce products capable of being sold abroad they must make more than one investment in ICT staff training (Leogrande, et al., 2022). In this sense, it is necessary to consider that only investment in research and development can truly support that technological innovation that allows companies to export medium and high technology products abroad (Laureti, et al., 2022).
- *Finance and support:* is an indicator consisting of the sum of three different sub-variables, namely: R&D expenditure in the public sector and Venture capital expenditures (Leogrande, et al., 2021). Therefore, the variable considers the possibility of financing research and development both with public resources and with venture capital investments. The data show that there is a negative relationship between the value of financial investment in research and development and the value of exports of medium and high technology products. From a strictly economic point of view, this relationship means that exporting companies need neither public nor private investments. This relationship could appear to be counterfactual. However, it should be borne in mind that exporting companies generally have a very efficient financial situation and therefore do not require external interventions. This consideration strengthens the hypothesis that exporting companies are also the most productive, competitive, and financially stable (Laureti, et al., 2020).
- *Innovative sales share:* is an indicator that considers the turnover deriving from new or significantly improved products. Such products can represent an innovation for the company or an innovation for the market in a broad sense. This value is considered as a percentage of the total turnover of the companies. There is a negative relationship between product or market innovations and the value of exports of medium and high technology products. This relationship may appear to be counterfactual. However, it should be noted that innovation that supports exports is generally based on investment in research and development. Innovations that are such for the company or for the market do not necessarily can generate products and services that are so innovative and interesting that they can be exported to foreign countries.
- *Innovators:* is an indicator made up of a set of three sub-variables, namely: SMEs with product or process innovations, SMEs with marketing or organizational innovations (Costantiello, *et al.* 2022), SMEs innovating in-house. These variables therefore explicitly consider the role of technological innovation generated at the level of small and medium-sized enterprises. However, even in this case this value is negatively correlated with the export of medium and high technology products. The rationale for this relationship can be found in the fact that technological innovations do not in themselves generate products that are attractive for export. In fact, innovative products that can be export-oriented are generally made because of investment in research and development (Costantiello, et al., 2021).
- *Most-cited publications:* is an indicator that considers the number of scientific publications that are included in the 10% of the most cited publications as a percentage of total scientific publications. The indicator tries to measure the quality of the research by assuming that the publications that are most cited are also those with the highest quality. There is a negative relationship between the presence of high-level scientific publications and the export of medium and high-tech products. It follows that for the

purpose of creating innovative products based on research and development that can be exported, it is not relevant that there are publications in the top 10% of citations. This is because scientific research and patents often have a very high level of innovation and are not necessarily accepted by the international scientific community as well-established solutions as well as helping to create products in great demand abroad.

- *Knowledge-intensive services exports:* is an indicator that considers exports of knowledge-intensive services as a percentage of total exports of services. Various sectors are considered in this regard, such as maritime, space and air transport, insurance, pension and financial services, the intellectual property sector, telecommunications, and other related services. This value is expressed in percentage terms with respect to the overall value of the services. This indicator considers the competitiveness of the service sector. There is a negative relationship between the turnover from the export of knowledge-intensive services and the export of medium and high technology products. This negative relationship can be better understood by considering the existence of a negative tradeoff between the export of services and the export of products (Leogrande, *et al.* s.d.).
- *Turnover share SMEs:* it is a variable that considers the share of turnover of small and medium-sized enterprises. Small and medium-sized enterprises have between 10 and 249 employees compared to the total turnover value of all enterprises. There is a negative relationship between the value of the turnover of small and medium-sized enterprises and the value of exports of medium and high-tech products. This relationship can be easily understood considering that small and medium-sized companies do not have the possibility to invest in research and development and therefore cannot create highly innovative products for export. Therefore, even if the turnover of small and medium-sized enterprises grows in percentage terms, there is still no growth in the overall value of exports of medium and high-tech products. In fact, in general, exporting companies tend to be large able to bear the costs of research and development and to orient themselves towards international competition (Leogrande, et al., 2020).
- *Employment Share Knowledge-intensive services (%):* is the percentage of employed in knowledge-intensive sectors in industrial activity sectors as a percentage of total employment. Knowledge-intensive services, for example, are those connected to the telecommunications sector, and create the conditions for the development of inputs that can be used by companies to promote technological innovations in the various sectors of activity. There is therefore a negative relationship between employment in technology-intensive sectors and exports of medium and high-tech products. This relationship can be understood considering that to produce products for export, it is necessary to invest in research and development. The fact that there is employment in the knowledge-intensive services sector, although appreciable, does not impact on the ability of firms to export (Laureti*, et al.* 2022).
- *Human resources:* it is a variable made up of three different variables, namely: new doctorate graduates, Population aged 25-34 with tertiary education and Lifelong learning. These are therefore variables that consider the value of human capital (Leogrande, et al., 2020). This variable is negatively correlated with the export value of medium and high technology products. It follows that the overall increase in the value of human capital at country level is not positively associated with the value of exports of medium and high technology products. That is, for when individually the presence of doctorates, tertiary education and lifelong learning is a positive fact for the export of high-tech products, the sum of the three variables is negatively associated with the export of high-tech products (Leogrande & Costantiello, 2021).
- *Government procurement of advanced technology products:* is an indicator that considers the demand for technologically advanced products that is required by the state. The state's ability to request technologically advanced products is arranged on a scale from 1 to 7. This indicator therefore measures the state's ability to stimulate technological innovation through public spending. There is a negative relationship between the export value of medium and high-tech products and the public demand for high-tech products. This negative relationship derives from the fact that exporting companies generally have a much higher level of technological innovation and research and development than what is generally required by the state in public procurement.
- *Buyer sophistication:* is an indicator that takes into consideration the degree of sophistication of consumers. That is, this indicator considers the fact whether the consumer in the purchase evaluates only the price or only the technological performance or a combination of price and technology. There is a negative relationship between the value of buyer sophistication and the export value of medium and high technology products. This relationship can be understood considering that the degree of sophistication of consumers at the country level could reduce exports of tech products. In fact, if the national market is sufficiently large and evolved to acquire high-tech products, then companies have

less incentives to export and instead have a greater chance of orienting themselves towards the internal market.

Figure 1. Estimation of the export value of medium and high technology products manufactured in Europe, average value



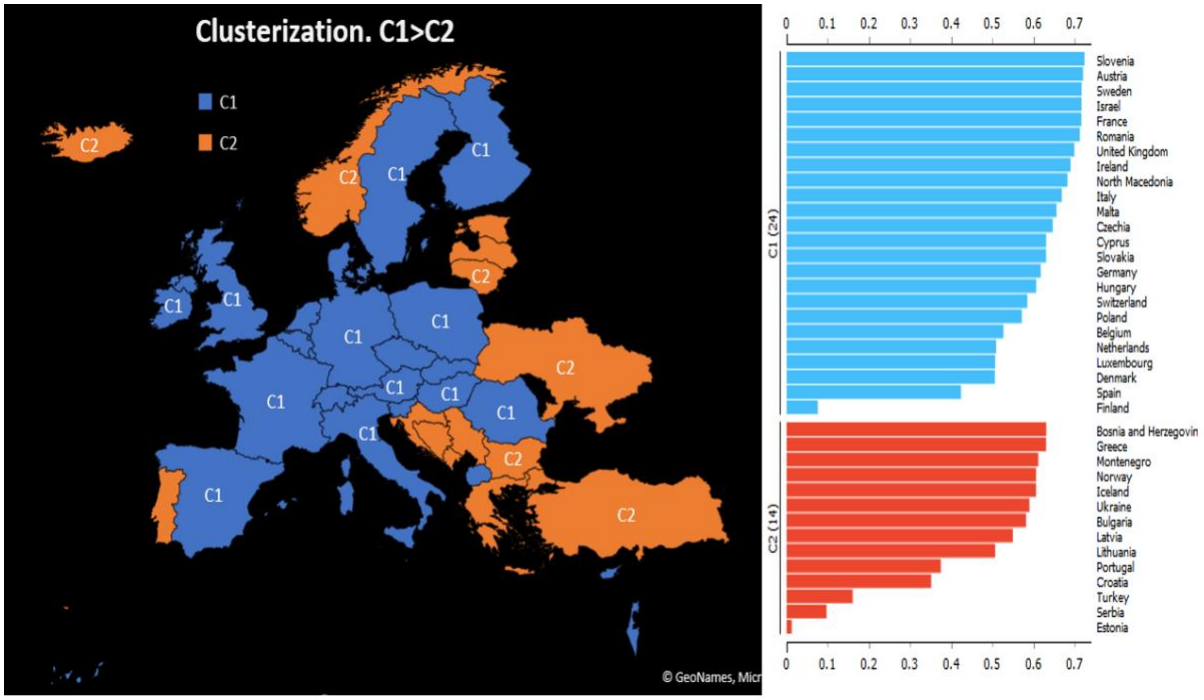
3. Ranking of European Countries and Clusterization with k-Means Algorithm

With reference to 2021 it is possible to create a ranking of European countries by value of exports of medium-high technology products. Hungary is in first place with a value of 143.53, followed by Slovakia with a value of 142.19 and the Czech Republic with a value of 139.35. In the middle of the table are Italy with a value of 93.54, followed by the Netherlands with a value of 92.68 and Belgium with an amount of 92.05 units. Montenegro closes the ranking with a value of 3.99 units, followed by Iceland and Norway with a value of 0.00. However, if we consider the variation between 2014 and 2021 then it appears that Greece is in first place with an increase in the export of medium-high technology products equal to 1240.90% equal to 30.57 units, followed by Bosnia with a value equal to 272.79% equal to an amount of 15.63 units and from Bulgaria with a value equal to 92.24% equivalent to an amount of 24.43 units. In the middle of the table there is the United Kingdom with a value equal to 18.19% equal to an amount of 15.32 units, followed by Belgium with a value equal to 16.63% equal to an amount of 13.12 units, and from Croatia with a variation equal to an amount of 14.60% equal to a value of 8.20 units. Malta closes the ranking with a value equal to -4.82% equal to an amount of -5.05 units, followed by Estonia with a value equal to -5.47% equal to an amount of -3.85 units and from Ukraine with a value of 46.99% equal to an amount of 23.36 units. On average, for the countries considered, the value of exports of medium and high-tech products increased by an amount equal to 63.48%, equal to an amount of 14.60 units. Through the clustering analysis with the k-Means algorithm optimized with the Silhouette coefficient it was possible to determine a cluster structure as indicated below:

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

From the point of view of the median, the value of the countries in cluster 1-C1 is equal to an amount of 105.83 while the value of the countries in cluster 2-C2 is equal to an amount of 48.12. The following order therefore derives from it, that is: C1 = 105.82 > C2 = 48.12.

Figure 2. Clusterization carried out with the Silhouette coefficient method



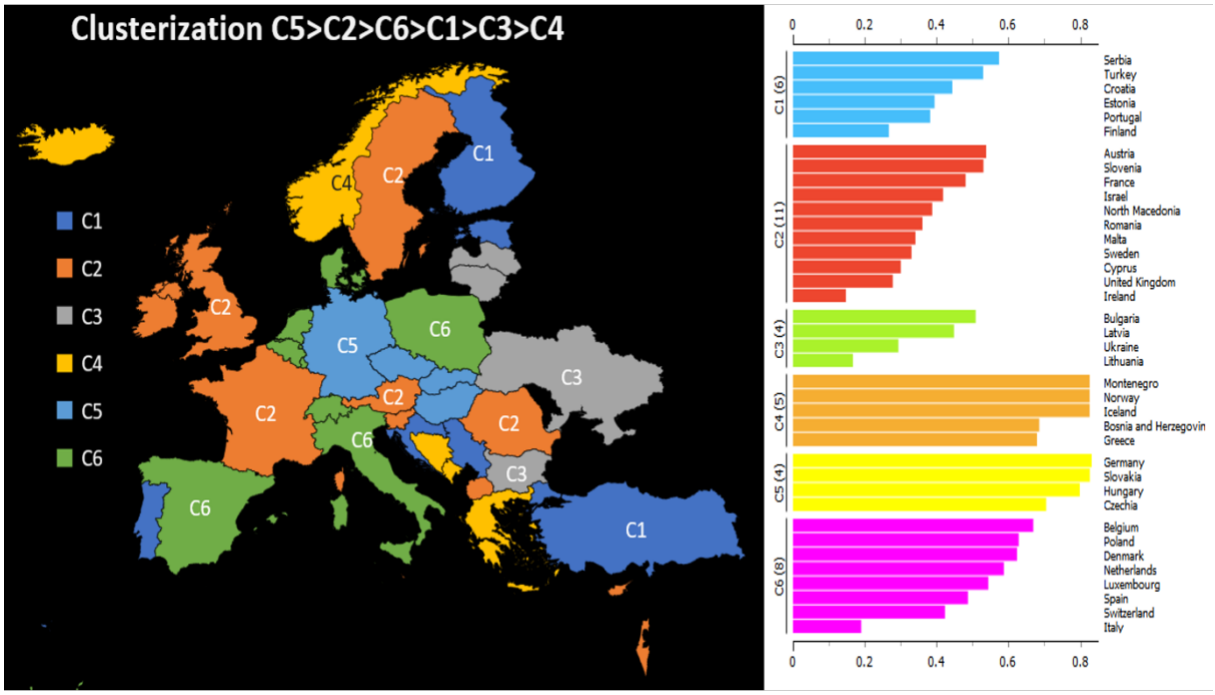
Note: As is evident, the geographical analysis does not bring to light the heterogeneity also present in the countries of central Europe and southern Europe in terms of export of medium and high technology products. For this reason, the clustering model with k-Means algorithm is proposed again with the Elbow method.

However, looking at clustering from a geographical point of view, it is possible to verify that the use of the Silhouette coefficient is a sufficient method to identify a representative number of clusters. In fact, as is evident in the two-cluster clustering from a geographical point of view, there is a large cluster that practically coincides with most Center and Southern European countries that would be dominant with respect to some countries of Eastern and Northern Europe. Therefore, to optimize clustering or to give greater representativeness, the Elbow method is used. With the Elbow method, 6 clusters are then identified as indicated below, that is:

- Cluster 1: Serbia, Turkey, Croatia, Estonia, Portugal, Finland;
- Cluster 2: Ireland, United Kingdom, Cyprus, Sweden, Malta, Romania, North Macedonia, Israel, France, Slovenia, Austria;
- Cluster 3: Bulgaria, Latvia, Ukraine, Lithuania;
- Cluster 4: Montenegro, Norway, Iceland, Bosnia and Herzegovina, Greece;
- Cluster 5: Germany, Slovakia, Hungary, Czechia;
- Cluster 6: Belgium, Poland, Denmark, Netherlands, Luxembourg, Spain, Switzerland, Italy.

From the point of view of the median, it is possible to sort the clusters according to the following order, that is: cluster C5 with a value of 140.77 units, followed by Cluster 2-C2 with a value of 110.44 units, followed by Cluster 6-C6 with a value of 92.36, followed by cluster 1-C1 with a value of 72.46, cluster 3-C3 with a value of 48.12 units and Cluster 4-C4 with a value equal to 3.99. Therefore, the following hierarchical structure of clusters derives based on the value of the median of the export of medium and high-tech products, that is: $C5 = 140.77 > C2 = 110.44 > C6 = 92.36 > C1 = 72.46 > C3 = 48.12 > C4 = 3.99$

Figure 3. Clusterization using the Elbow method with indication of 6 clusters and representation of the heterogeneity of European economic-industrial structure



Note: Cluster 5 is the dominant cluster and represents a set of economies closely connected with the German economy

From a strictly geographical point of view, clustering carried out with the Elbow method turns out to be much more efficient than clustering with the Silhouette coefficient in terms of maximizing heterogeneity. In fact, in clustering it is important to grasp the diversity of the various countries since a representation with only two clusters in a context such as the European one made up of a large variety of capitalism would make no sense. Geographically, there is therefore the dominance of Germany, the Czech Republic, Slovenia, and Hungary, over France, UK, Sweden, Austria, and Romania. At the bottom of the ranking are Italy, Spain, Poland, the Netherlands, Belgium, and Denmark. This representation is much more identifying than the overall value of European heterogeneity in terms of production systems. And in fact, Cluster 5-C5 or the dominant cluster is none other than the set of economies most connected to Germany from a strictly productive-industrial point of view.

4. Network Analysis with the Manhattan Distance

A network analysis using the Manhattan distance is presented below. Four different complex network structures and two simplified network structures are identified. There is a complex network structure between Poland, Belgium, Denmark, and the Netherlands as follows:
There is a relationship between Poland and Belgium for a value of 0.21;

- Belgium is connected with Poland for a value of 0.21 and with Denmark for a value of 0.15;
- Denmark has a connection with Belgium for a value of 0.15 and with the Netherlands for a value of 0.17;
- The Netherlands has a connection with Denmark worth 0.17 units.

There is a complex network structure established between Ireland, Romania, Sweden and Israel. Particularly:

- There is a relationship between Ireland and Romania for a value of 0.2;
- Romania has a connection with Ireland for a value of 0.2, with Israel for a value of 0.17 and with Sweden for a value of 0.22;
- Israel has a connection with Romania for a value of 0.17 and with Sweden for a value of 0.21;
- Sweden has a connection with Romania for a value of 0.22 and with Israel for a value of 0.21.

There is a structured relationship between Slovenia, Austria, and France, namely:

- Slovenia has a connection with Austria with a value of 0.19;
- Austria has a connection with Slovenia for a value of 0.19 and with France for a value of 0.11;
- France has a connection with Austria for a value of 0.11 units.

There is a connection between Slovakia, Germany, and Hungary namely:

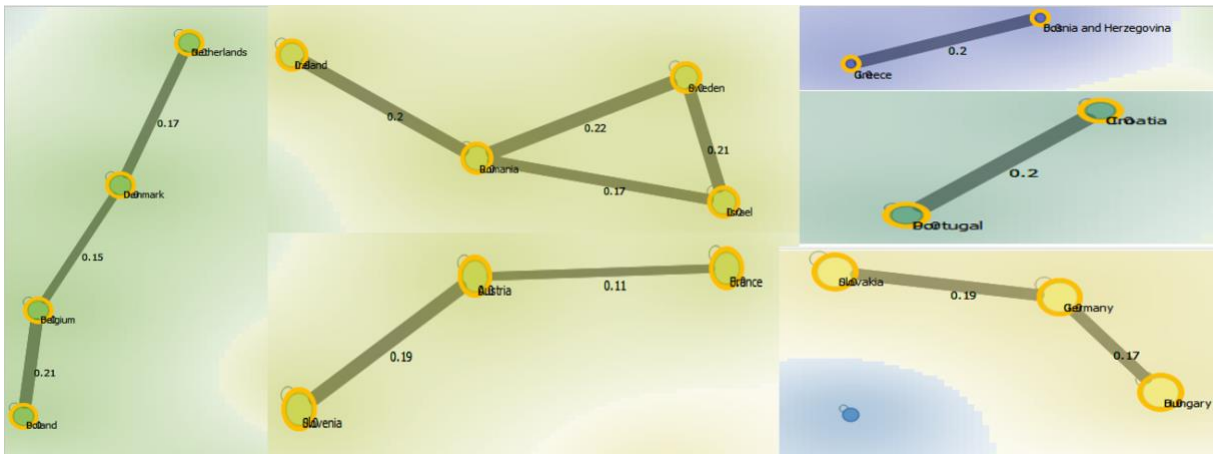
- Slovakia has a connection with Germany for a value of 0.19;

- Germany has a connection with Slovakia for a value of 0.19 and with Hungary for a value of 0.17;
- Hungary has a connection with Germany for a value of 0.17 units.

There are also two simplified network structures or consisting of two connections. In particular:

- There is a relationship between Greece and Bosnia equal to a value of 0.2;
- There is a relationship between Portugal and Croatia for a value of 0.2.

Figure 4. Network analysis using the Manhattan distance



Note: As you can see, the most connected nation is Romania

5. Machine Learning and Predictions with Original Data

A prediction is presented below using a comparison between various machine learning algorithms used for prediction. Specifically, 80% of the data was used for the training of the algorithms while the remaining 20% was used for the actual prediction. Specifically, the algorithms were analyzed on the basis of the ability to reduce statistical errors or MSE, RMSE, MAE and maximize the R2. Therefore, the following ordering in terms of predictive efficiency derives from it, that is:

- SGD with a payoff value of 5;
- Linear Regression with a payoff value of 7;
- Gradient Boosting with a payoff value of 12;
- AdaBoost with a payoff value of 17;
- Random Forest with a payoff value of 22;
- kNN with a payoff value of 27;
- SVM with a payoff value of 28;
- Tree with a payoff value of 29;
- Constant with a payoff value of 33;
- Neural Network with a payoff value of 40.

Therefore, the most performing algorithm is the SGD. Through the application of the SGD algorithm, it is possible to verify that there are some countries for which an increase in the value of the export of medium and high technology products is predicted and countries for which a reduction is expected. The countries for which the export growth of medium and high-tech products is predicted are:

- Montenegro with a change from an amount equal to 3.99 up to a value of 7.35 or a change equal to an amount of 3.35 units equal to an amount of 84.03%;
- Latvia with a variation from an amount of 45.33 units up to a value of 53.22 units or equal to a value of 7.88 units equal to an amount of 17.40%;
- Cyprus with a variation from an amount of 105.29 units up to a value of 114.13 units or equal to a value of 8.84 units equal to a value of 8.39%;
- France with a variation from an amount of 109.65 units up to a value of 116.85 units or equal to an amount of 7.19 units equal to a value of 6.56%;
- United Kingdom with a variation from an amount of 99.54 units up to a value of 105.49 units or equal to a variation of 5.95 units equal to an amount of 5.97%;
- Italy with a variation from an amount of 93.54 units up to a value of 98.06 units or equal to a variation of 4.52 units equal to a value of 4.83%;

- Spain with a variation from an amount of 79.71 units up to a value of 82.43 units or equal to a value of 2.71 units equal to a value of 3.40%;
- Croatia with a variation from an amount of 64.34 units up to a value of 66.40 units or equal to a value of 2.05 units equal to a value of 3.2%;
- Germany with a variation from an amount of 138 units up to a value of 142.15 units or equal to a value of 4.14 units equal to a value of 3.00%;
- Ukraine with a variation from an amount of 26.35 units up to a value of 27.08 units or equal to a value of 0.73 units equal to an amount of 2.77%;
- Bulgaria with a variation from an amount of 50.19 units up to a value of 52.24 units or equal to a value of 1.33 units equal to a value of 2.61%;
- Switzerland with a variation from an amount of 100.00 units up to a value of 102.00 units or equal to a value of 1.97 units or equal to a value of 1.96%;
- Netherlands with a variation from an amount of 92.67 units up to a value of 94.42 units or equal to a variation of 1.74 units equal to a value of 1.88%;
- Poland with a variation from an amount of 88.49 units up to a value of 89.64 units or equal to a value of 1.15 units equal to a value of 1.30%;
- Romania with a variation from an amount of 110.43 units up to a value of 111.73 units or equal to a value of 1.30 units equal to a value of 1.17%;
- Estonia with a variation from an amount of 66.43 units up to a value of 67.13 units or equal to an amount of 0.7 units equal to an amount of 1.05%;
- Austria with a variation from an amount of 112.69 units up to a value of 113.51 units or equal to a value of 0.82 units equal to an amount of 0.73%;
- Malta with a variation from an amount of 99.70 units up to a value of 100.40 units or equal to a value of 0.69 units equal to an amount of 0.70%;
- Sweden with a variation from an amount of 106.37 units up to a value of 106.62 units or equal to a value of 0.25 units equal to a value of 0.24%;
- Slovakia with a variation from an amount of 142.19 units up to a value of 142.25 units or equal to a variation from a value of 0.062 units up to a value of 0.04%.

However, the SGD algorithm also predicts a reduction in the export performance for medium and high technology products for the following countries, i.e.:

- Finland with a variation from an amount of 80.66 units up to a value of 80.58 units or equal to a variation of -0.07 units equal to a value of -0.098%;
- Hungary with a variation from an amount of 143.53 units up to a value of 142.51 units or a variation equal to an amount of -1.01 units equal to a value of -0.70%;
- Slovenia with a variation from an amount of 116.45 units up to a value of 115.50 units or equal to a value of -0.95 units equal to a value of -0.81%;
- Czech Republic with a variation from an amount of 139.35 units up to a value of 138.07 units or equal to a value of -1.27 units equal to a value of -0.91%;
- Serbia with a variation from an amount of 75.05 units up to a value of 73.99 units or equal to a value of -1.06 units equal to a value of -1.42%;
- Belgium with a variation from an amount of 92.04 units up to a value of 90.67 units or equal to a value of -1.36 units equal to a value of -1.48%;
- Turkey with a variation from an amount of 84.27 units up to a value of 82.39 units or equal to a value of -1.87 units equal to a value of -2.22%;
- Denmark with a variation from an amount of 94.81 units up to a value of 92.28 units or equal to a value of -2.52 units equal to a value of -2.66%;
- Portugal with a variation from an amount of 69.87 units up to a value of 67.96 units or equal to a variation of -1.90 units equal to a value of 2.73%;
- Luxembourg with a variation from an amount of 85.27 units up to a value of 81.94 units or equal to a value of -3.33 units equal to a value of -3.91%;
- Ireland with a variation from an amount of 119.99 units up to a value of 111.00 units or equal to a value of -8.98 units equal to an amount of -7.48%;
- Lithuania with a variation from an amount of 63.49 units up to a value of 58.71 units or equal to a variation from an amount of -4.77 units equal to a value of -7.52%;

- Bosnia with a variation from an amount of 21.35 units up to a value of 19.58 units or equal to a value of -1.77 units equal to a value of -8.30%;
- North Macedonia with a variation from an amount of 130.76 units up to a value of 118.26 units or equal to a value of -12.49 units equal to a variation of a value of -9.55%;
- Israel with a variation from an amount of 124.25 units up to a value of 111.68 units or equal to a value of 12.57 units equal to an amount of -10.12%;
- Greece with a variation from an amount of 33.03 units up to a value of 16.35 units or equal to a variation of -16.68 units equal to a value of -50.49%.

6. Machine Learning and Predictions with Augmented Data

An analysis with augmented data is presented below. The augmented data is obtained by adding the prediction to the previous time series. A new predictive analysis is then carried out by comparing the various machine learning algorithms. Even in the case of augmented data as in the case of the original data, 10 different machine learning algorithms are proposed for prediction. The algorithms are analyzed on the basis of their ability to maximize R-squared and minimize statistical errors, *i.e.,* Mean Squared Error, Root Mean Squared Error, Mean Absolute Error. Eighty percent of the data was used to train the algorithm while the remaining 20% was used for prediction. Through this comparison it is possible to carry out an ordering of the algorithms based on the predictive capacity with the following result, that is:

- Linear Regression with a payoff value of 4;
- SGD with a payoff value of 8;
- Gradient Boosting with a payoff value of 12;
- AdaBoost with a payoff value of 16;
- Random Forest with a payoff value of 20;
- kNN with a payoff value of 24;
- Tree with a payoff value of 28;
- SVM with a payoff value of 32;
- Constant with a payoff value of 36;
- Neural Network with a payoff value of 40.

Therefore, through the analysis of the performative capacity of the algorithms it appears that the most performing algorithm is Linear Regression. Therefore, through the use of the Linear Regression algorithm it is possible to predict a growth in export performance for the following countries, that is:

- Montenegro with a variation from an amount of 7.35 units up to a value of 8.66 units or equal to a value of 1.30 units or equal to a value of 17.81%;
- Ukraine with a variation from an amount of 27.08 units up to a value of 30.28 units or equal to a variation of 3.2 units equal to a value of 11.82%;
- North Macedonia with a variation from an amount of 118.26 units up to a value of 123.71 units or equal to an amount of 5.44 units equal to a value of 4.60%;
- Bosnia with a variation from an amount of 19.58 units up to a value of 20.02 units or equal to a variation of a value of 0.44 units equal to a value of 2.27%;
- Malta with a variation from an amount of 100.40 units up to a value of 101.88 units or equal to a value of 1.41 units equal to a value of 1.47%;
- United Kingdom with a variation from an amount of 105.49 units up to a value of 107.03 units or equal to a value of 1,535 units equal to a value of 1.45%;
- Latvia with a variation from an amount of 53.22 units up to a value of 53.82 units or equal to a variation from an amount of 0.6 units equal to a value of 1.12%;
- Serbia with a variation from an amount of 73.99 units up to a value of 74.74 units or equal to a value of 0.75 units equal to a value of 1.02%;
- Finland with a variation from an amount of 80.58 units up to a value of 81.31 units or equal to a value of 0.72 units equal to a value of 0.90%;
- Spain with a variation from an amount of 82.43 units up to a value of 83.16 units or equal to a value of 0.72 units equal to a value of 0.87%;
- Austria with an increase from an amount of 113.51 units up to a value of 114.31 units or equal to a value of 0.798 units equal to a value of 0.70%;
- Italy with a variation from an amount of 98.06 units up to a value of 98.58 units or equal to a value of 0.51 units equal to a value of 0.52%;

- Germany with a variation from an amount of 142.15 units up to a value of 142.84 units or equal to a value of 0.68 units equal to a value of 0.48%;
- Poland with a variation from an amount of 89.64 units up to a value of 90.06 units or equal to a variation of 0.41 units up to a value of 0.46%;
- Switzerland with a variation from an amount of 102.00 units up to a value of 102.42 units or equal to a variation of 0.41 units equal to an amount of 0.41%;
- Greece with a variation from an amount of 16.35 units up to a value of 16.42 units or equal to a value of 0.06 units equal to a value of 0.40%;
- Hungary with a change from an amount of 142.51 units equal to a value of 142.57 units equal to a value of 0.05 units equal to a value of 0.41%;
- Czech Republic with a variation from an amount of 138.07 units up to a value of 138.10 units or equal to a value of 0.03 units equal to a value of 0.022%:

However, the Linear Regression algorithm also predicts for some countries the reduction in the export value of medium and high-tech products, namely:

- The Netherlands with a reduction from an amount of 94.42 units up to a value of 94.36 units or equal to a change of a value equal to -0.05 units equal to a value of -0.059%;
- Israel with a variation from an amount of 111.68 units up to a value of 111.60 units or equal to a value of -0.073 units equal to a value of -0.06%;
- Sweden with a variation from an amount of 106.62 units up to a value of 106.47 units or equal to a value of -0.153 units equal to a value of -0.14%;
- Ireland with a variation from an amount of 111.00 units up to a value of 110.69 units or equal to a value of -0.31 units equal to a value of -0.28%;
- France with a variation from an amount of 116.85 units up to a value of 116.32 units or equal to a variation of an amount equal to -0.52 units equal to a value of -0.44%; Romania with a variation from an amount of 111.73 units up to a value of 111.20 units or equal to a variation of -0.53 units equal to a value of -0.47%;
- Croatia with a variation from an amount of 66.40 units up to a value of 66.04 units or equal to a value of -0.35 units equal to a value of -0.54%;
- Luxembourg with a variation from an amount of 81.94 units up to a value of 81.31 units or equal to a value of -0.61 units equal to a value of -0.74%;
- Lithuania with a variation from an amount of 58.71 units up to a value of 58.27 units or equal to a value of -0.44 units equal to a value of -0.75%;
- Estonia with a variation from an amount of 67.13 units up to a value of 66.61 units or equal to a variation of -0.51 units equal to an amount of -0.77%;
- Belgium with a variation from an amount of 90.67 units up to a value of 89.92 units or equal to a variation of -0.75 units prior to an amount of -0.83%;
- Slovakia with a variation from an amount of 142.25 units up to a value of 140.97 units or equal to a value of -1.2 units equal to an amount of -0.900%;
- Denmark with a variation from an amount of 92.28 units up to a value of 91.37 units or equal to a value of -0.90 units equal to a value of -0.98%;
- Slovenia with a variation from an amount of 115.50 units up to a value of 114.2 units or equal to a value of -1.30 units equal to a value of -1.13%;
- Portugal with a variation from an amount of 67.96 units up to a value of 66.80 units or equal to a variation of -1.1 units equal to a value of -1.70%;
- Bulgaria with a variation from an amount of 52.24 units up to a value of 51.24 units or equal to an amount of -1.00 units equal to -1.9%;
- Turkey with a variation from an amount of 82.39 units up to a value of 80.50 units or equal to a value of -1.8 units equal to an amount of -2.24%;
- Cyprus with a variation from an amount of 114.13 units up to a value of 107.13 units or equal to a value of -7.00 units equal to a value of -6.13%;
- Norway with a variation from an amount of 5.3 units up to a value of 4.79 units or equal to a value of -0.50 units equal to a value of -9.6%;
- Iceland with a variation from an amount of 5.86 units up to a value of 4.8 units or equal to a variation of -1.01 units equal to an amount of -17.38%.

From the point of view of the comparison between the prediction with the original data and the prediction with the augmented data, it is evidently evident that the prediction with the augmented data has a greater statistical efficiency. First, it should be emphasized that the best performance algorithms are different between prediction with Original Data-OD and prediction with Augmented Data-AD. In fact, in the case of the OD the best performing algorithm is SGD while in the case of the AD the best performing algorithm is Linear Regression. However, it must be verified that the predictive efficiency of Linear Regression exceeds that of the SGD in terms of minimization of the MAE. In fact, while the EAW of the SGD in the OD is equal to 0.0022131, the EAW of the AD is equal to 0.000. There is therefore a greater predictive efficiency in the use of AD than OD.

Table 2. Comparison between the statistical results of the prediction using the Original Data-OD and the prediction using the Augmented Data-AD

Augmented Data					
Model		MSE	RMSE	MAE	R2
1	Linear Regression	0,00000000	0,00000000	0,00000000	1,00000000
2	SGD	0,00043763	0,00815945	0,00742868	0,99956200
3	Gradient Boosting	0,00056909	0,01023310	0,01389510	0,99943100
4	AdaBoost	0,00228283	0,03046950	0,02624640	0,99771700
5	Random Forest	0,00406267	0,04550900	0,04534370	0,99593700
6	kNN	0,00753735	0,06804330	0,06297000	0,99246300
7	Tree	0,02130730	0,12732900	0,07889090	0,97869300
8	SVM	0,21765700	0,45419200	0,35572300	0,78234300
9	Constant	0,28887600	0,52673200	0,45520500	0,71112400
10	Neural Network	1,00000000	1,00000000	1,00000000	0,00000000
Original Data					
Model		MSE	RMSE	MAE	R2
1	SGD	0,000000000	0,000000000	0,002213100	1,000000000
2	Linear Regression	0,000365967	0,002773800	0,000000000	0,999746000
3	Gradient Boosting	0,003827250	0,011095200	0,014934800	0,998475000
4	AdaBoost	0,008530410	0,025241700	0,339880000	0,996188000
5	Random Forest	0,011845700	0,049401600	0,467976000	0,989835000
6	kNN	0,016345800	0,063936300	0,630898000	0,988056000
7	Tree	0,198295000	0,081494500	0,600029000	0,983736000
8	SVM	0,198295000	0,408609900	0,320196400	0,801779000
9	Costant	0,261843000	0,479050800	0,413791600	0,738247000
10	Neural Network	1,000000000	1,000000000	1,000000000	0,000000000

Conclusion

In this paper, econometric and machine learning techniques have been used to predict exports of medium and high technology products manufactured in Europe. The data show that the variables that more than others have a positive impact in promoting exports of medium and high technology products are "Average Annual GDP Growth", "Total Entrepreneurial Activity" and "Sales Impacts". On the contrary, the variables that negatively impact the most are "Human Resources", "Government and Procurement of Advanced Technology Products" and "Buyer Sophistication". In general, econometric analysis shows that the variables that have the greatest chance of generating export growth are those associated with investments in research and development, entrepreneurial capacity widespread in the country and orientation to sales. Clustering with k-Means algorithm shows that there is a wide heterogeneity of geographical areas in Europe with reference to the ability to export medium and high technology products. The most advanced area by far is the one strictly connected to the German economy and including the Czech Republic, Slovakia, and Hungary. On the contrary, Poland and Italy are among the countries that have the least ability to export medium and high technology products. The network analysis confirmed the presence of countries that are more connected than others with the identification of four complex network structures and two simplified network structures. Finally, a prediction was made through a performance comparison between 10 different machine learning algorithms evaluated based on the ability to reduce statistical errors and maximize

the R-square. The analysis was carried out both with the Original Data-OD and with the Augmented-Data. The best performing algorithm with Original Data-OD is SGD. The best performing algorithm with Augmented Data-AD is Linear Regression. However, prediction with Augmented Data turns out to be more efficient than prediction with Original Data-OD with a reduction of the MAE equal to 0.0022131.

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