American Journal of Humanities and Social Sciences Research (AJHSSR)
e-ISSN:2378-703X
Volume-4, Issue-8, pp-91-126
www.ajhssr.com
Research Paper Open Access

The Determinants of Innovation in European Countries in the period 2010-2019

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ABSTRACT:We analyze data from European Innovation Scoreboard for 36 countries in the period 2010-2019. We estimate the determinants of the "*Innovation Index"*in respect to 14 classes of variables. We found that the ability to innovate is negatively associated with "*Business and Entrepreneurship"* and "*Performance and Structure of the Economy*". The ability to innovate is positively associated to "*Attractive Research Systems*", "*Demography*", "*Employment Impacts*", "*Finance and Support*", "*Firm Investments*", "*Governance and Policy Framework*", "*Human Resources*", "*Innovation-friendly Environment*", "*Innovators*", "*Intellectual Assets*", "*Linkages*" "*Sales Impact*".

I. INTRODUCTION

In this article we analyze the determinants of the innovation for European countries. We estimate the innovation index for 36 countries[4] in the period 2010-2019. Data are from the Innovation Index Scoreboard of the European Union. We are interested in investigating the conditions that can boost innovation in European countries. In particular we focus either on endogenous and on exogenous variables. The role of innovation in economic theory is quite controversial. Innovation economics is devoted to analyze the role of innovation in firms. In particular the focus on innovation can be traced back in a of Schumpeter entitled "*Capitalism, Socialism and Democracy*" (Schumpeter, 2010). Schumpeter considers the difference between invention and innovation. Inventions are new products and services. Innovations are innovative modifications of products and services. The role of innovation is important to find a justification for the role of technological changes. The development of industrial, financial, and economic system cannot be considered without a specific evaluation of the role of technology in boosting economic growth. And the development of technology is entirely reconducted to the development of innovation. Innovations can improve the role of technology and by this way they can generate a new path of economic growth. Technology can participate directly in the production process of knowledge, especially thanks to the development of the science of information. Artificial intelligence can effectively produce knowledge and replace the humans in many creative, scientific, and professional activities. The usage of artificial intelligence can generate a sort of "*artificial knowledge*". In this sense the progress of the capitalism and market society can be assured by the artificial intelligence, but the role of human capital and human knowledge can be effectively marginalized by artificial intelligence. Progress, technology, science, and also creative products can be effectively realized by the use of artificial intelligence and this can change also the applicability of the Solow's Theory of Economic Growth (Solow, 1956). In effect artificial intelligence can write articles either for newspaper either for scientific journals and can realize also immaterial and creative products such as for example music, or narratives or also can evaluate among different film scripts (Tegmark, 2017). But what is more important for the development of the industrial system is the fact that artificial intelligence can also design new firms and modes of production creating effective plants and generating new methodologies in management and governance. Artificial intelligence can also be successful used in the process of decision making applied in finance and in the context of risk management to optimize the revenues and minimize the costs. The possibility of artificial intelligence to generate new forms of cultural and scientific knowledge, to project new technologies and implement them creating effectively new productive plants able to

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

realize new products and services can increase the degree of capitalism and market economy to unprecedent results. But this great advantage in the economic and productive system is based essential on the deprivation and on the devaluation of the human capital and of the social capital. The contribution of humans to the productive process can be effectively completely marginal and in a certain sense it is possible to consider the human social contribution of workers as that of useless class (Harari, 2017). Workers are less important for the capitalist systems either in the agriculture and extractive sector, either in the industrial sector and, thanks to the Fourth Industrial Revolution also in the service sectors, due to the fact that artificial intelligence has good performance in the process of creating immaterial goods based on scientific and professional knowledge. And in a certain sense we can say that the revolution of informatics can have on the development of the industrial system an analogous role similar of that of agricultural revolution and of mechanization of industry that is the reduction of jobs. Technology can increase productivity creating unemployment. The development of capitalism and market economy can be realized through technology with a detrimental role of human and social capital.

Innovation economics considers three elements: technology, institutions, and entrepreneurships.

On an institutional point of view, liberal democracies of western civilization, either with their problem of social justice and social discrimination, seem more able to defend and promote a dynamic system of innovation realized through technologies. Even if the presence of a democratic system is not a theoretical prerequisite for the development of a performative economic system based on innovation and technologies in effect historical data shows that democracies performs better in respect to hierarchal and dictatorial system in promoting innovation and technologies. Western civilization has created the conditions for the development of innovations and technologies. For this reason, the analysis of innovation economics, either in preserving its focus on technology and in particular on the role of knowledge considers also the role of institutions and the institutional foundation of the economic and political system. Western civilization has created the conditions to the increase of innovation and technology due to the presence of liberal democracies and due also to the affirmation of the idea of freedom of science and research (Leogrande, et al., 2020). Western democracies and institutions have also created the conditions for the rationalization process of the innovation in the dynamic of the industrial system creating organizations such as department of research and innovation that are professionally engaged in the process of scientific discovery. In the economics of innovation, the evolution of the institutional profile of the economy is a key to discover the process of knowledge accumulation and of technological creation.

The idea of innovation and its role in economics can be better understood in an evolutionary approach, that is the idea that economic systems following a path of development based on their inner characteristics. The main determinants of the economics of innovations are:institutions, entrepreneurs and technological change. The functioning of the innovation process and technological development is reconducted to the dynamics of creative-destruction. Creative destruction is the main concept in evolutionary economics. Innovations and inventions have a twofold impact: they create new products and services but in the same act of creation they also destroy old products and services through obsolescence reducing the liquidity of their markets. In effect new products and services can destroy the old market and to acquire all the customers and their financial resources. By this way, the same act of creation of goods and services for new markets generate a destruction of goods and services in old markets. But the value of new goods and services created tends to be higher in respect to the value of old goods and services since the new goods and services are based on technology and innovation.

$$\boldsymbol{ValueOfCreationOfNewMarkets + ValueOfInnovations > ValueOfDestructionOfOldMarkets}$$

And since

$$\boldsymbol{ValueOfInnovations = Institutions + Technology + Enterpreneurship}$$

We have that

$$\boldsymbol{ValueOfCreationOfNewMarkets + Institutions + Technology + Enterpreneurship > ValueOfDestructionOfOldMarkets}$$

Even if the value of the creation of new markets is equal to the value of the destruction of old markets there are positive elements in the context of innovation that is due to the intrinsic value of technology and innovation.

The value of the creation of new markets differs from the value of destruction of old market by a factor that is the value of innovation. In this sense the entire process of economic growth can be explained in the process of technological innovation. Innovation can create value to sustain the process of economic growth. Due to the presence of the Value of Innovation the destructive part of the creation of new goods and services can generate value added that is able to increase the level of economy. This is an evolutionary process that create the condition of change in capitalist and market economy with the continuous creation of new products and services

and the associated destruction of old technologies, institutions, products, and services. In the evolutionary definition of the economy the innovation change is always a change in institutions, in technology and in entrepreneurship.

Innovations and institutions. Institutions can promote, can be part of or can be destroyed by the process of innovation. In the contemporary democracies the entire process of innovation can be promoted by institutions, public and private programs, that are able to offer incentive to increase the level of innovation among institutions and organizations. The presence of financial incentives can promote the process of research and development among firms and economic organizations. This is a pro-innovation political environment that has been created in the context of western democracies were the connection among political engagement, technological innovations, research institutions and the industrial and productive system as historical roots and is considered as one of the main drivers of the economic growth. But in certain context institutions are also part of the innovation process especially when the State creates some program or destinate some public resources to ends valuable in the sense of innovation. This is the case for example of public universities (Leogrande, et al., 2019), or public research centers or also is the case of the tax subsidies in respect to innovation.

But there are also institutions that are destroyed by the innovation such as for example rent-seeking and extractive regimes that have lost their productivity ability due to the absence of pro-innovative policies (Acemoglu & Robinson, 2012). Institutions in this case can be effectively destroyed by the absence of innovation for the fact that they become inefficient and have difficulty to guarantee products, services and economic growth to their populations. Policy makers must choose if promote, participate or being destroyed from the innovation. But western democracies and western civilization have shown how to deal with the complex topic of promoting innovation and mitigate its disruptive consequences in a process of prosperity and increasing productive capacity.

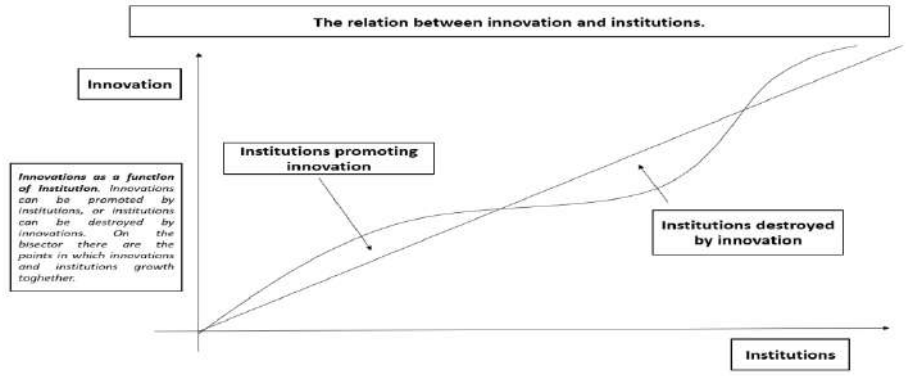

Figure 1. The relationship between innovation and institutions.

Innovation and technology. Technology is more affected to the process of innovation due to the fact that the process of innovation is in general a process of technological innovation. The development of technology requires some pre-conditions that are either the presence of a human capital that is oriented to the process of research and development through knowledge, either the presence of an industrial system i.e. an entrepreneurial environment that is more oriented to apply on an industrial scale the technological innovation. In particular it is important for entrepreneurs to be able to generate new products and services through the usage of innovation, to build new firms, and to translate the scientific and professional knowledge in organizational and productive plants that are able to generate products and services. The presence of human capital able to realize research and development project and to accumulate and produce knowledge, either in the form of patents, is an essential element in the process of innovation. But all the knowledge and patents and the intellectual property rights that are associated to the new discoveries are not able to produce wealth, income and innovation without the presence of pro-active entrepreneurs. To generate innovation, it is necessary that entrepreneurs use their economic organizations to the production of goods and services. Technologies are under the axe of obsolescence due to the continuous process of innovation and creative destruction.

Innovation and entrepreneurship. Entrepreneurs have two different possibilities in respect to innovation:

- *create innovations:*entrepreneurs can create innovations investing resources in the process of generating new products and services. For example, entrepreneurs can invest more in research and development to win against the competitors and control the market. Markets that are oriented to pure competition are less devoted to investing in innovations especially in respect to markets that are more oligopolistic and hierarchical. The incentive to invest in research and development can be a strategy to acquire market power, even if there are some sectors in which the minimum level of knowledge required to have access to a certain market is high. This is for example the case of the "*knowledge economy*" in which firms have to invest in the process of innovation

continuously not to take over the control of the market, but simply to stay in the market at a basic competitive standard.

- *apply innovations:* entrepreneurs can buy innovation and apply it in their economic organizations such as for example in the case of patents and intellectual property rights. In this case firms and productive organizations must adjust innovations to the productive system. Firms must find methodologies to translate innovations into practices that can be effectively applied in the productive system. This continuous process of adaptation of innovations and knowledge from patents and intellectual property rights into productive practices make the entrepreneur relevant in the process of technological change. Entrepreneurs are relevant in the sense of innovations either for the fact that they must change their economic organizations continuously to find efficient path in the process of implementation of innovations into the productive system.

Knowledge it is not sufficient to create a society devoted to innovation. To transform knowledge into innovation it is important to implement also technological change, to design pro-innovation institutions and policies, and to have entrepreneurs that are either able to produce innovation in the production process either to apply scientific and professional knowledge into their productive plants.

Innovations and economic growth. Innovations and technological innovation can overcome the limitations of total factor productivity and produce growth. The continuous activity of re-organization and renewal of the productive system that has been possibly through the technological system is a key factor in the development of capitalism and market economy. New ideas, new projects, new intellectual propriety rights and patents are effectively introduced in the context of the productive system through financial markets, or venture capitalism. In some cases, there are public incentives to produce and promote certain innovations and discoveries. But financial markets can be inefficient in the process of promoting innovations and technological change creating the conditions for an underperforming of the economic growth. Not all the innovations and inventions that financial markets are able to sustain and promote can boost the economic productivity of firms in the sense of the generation of new and more performative goods and services.

In this sense either the public incentives either the financial markets can be largely inefficient in promoting the implementation of innovations that are able to determine an increase in productivity that can be also compatible with social and public goals. The inefficiency of financial markets and public incentive questions the model of governance of these institutions suggesting that the idea of maximizing profits cannot be considered a structural solution for problems that are characterized by the interest of multiple stakeholders (Ferri & Leogrande, 2015). The inefficiency of financial markets and public incentive in respect to the promotion of innovations can only partially be covered by the self-interest of entrepreneurs in their effort to increase productivity and profit, and by the sensibilities of communities and constituencies in respect to the possible negative externalities associated to certain technologies and innovations. In this sense, even if innovations can explain economic growth, the degree of innovations and technological change that is feasible for the firms is always under the degree of the potential output due to the misallocation of financial resources in respect to innovations that is realized by financial markets and public incentives.

$$\boldsymbol{PotentialOutput_t = RealOutput_{t-1} + Innovations_{t-1} - DistortedFinancialIncentives_{t-1}}$$

Where distorted financial incentives can be considered

$$\begin{aligned}\boldsymbol{DistortedFinancialIncentives} &= \boldsymbol{Shortermism + ProfitMaximization + ShareholderValueMazimization} \\ &\boldsymbol{+ MarketPower + InformativeAsymmetries + RentSeeking + Oligopolies} \\ &\boldsymbol{+ Monopolies}\end{aligned}$$

Distorted financial incentives are a force that can destroy the entire productive system. The impact of distorted financial incentives in some cases can generate financial crisis destroying either the value of innovations either the value of real output. We can define a financial crisis as a condition in with distorted financial incentives has an increasing value in respect to RealOutput and Innovations.

$$\boldsymbol{DistortedFinancialIncentives_{t-1} > RealOutput_{t-1} + Innovations_{t-1} \rightarrow FinancialCrisis}$$

II. LITERATURE REVIEW

Artificial intelligence, Automation,and Innovation. Artificial intelligence is the main element in the context of innovation. The fact that a country invest in artificial intelligence is certainly a signal of the presence of aability to innovate in the country. (Acemoglu & Restrepo, 2020)consider therole of artificial intelligence in the process of labor destroying. In this sense there is a positive relation between innovations and unemployment. Automation substituteslabor without the possibility to restore the loss of jobs. Artificial intelligence and

automation generate social diseases such as stagnating labor demand, inequality and create the condition for the economic irrelevance of the workforce. Artificial intelligence seems to play a zero-sum game on the ability of the workforce. The promise of an Artificial Intelligence able to create social sustainable economic outputs is neglected.

(Acemoglu & Restrepo, 2019)afford the question of the zero-sum game between the development of automation in the industrial production and the labor force. Automation has a relevant social cost that consists in the creation of massive unemployment. The zero-sum game between automation and jobs does not create the condition for the end of work or for the takeover of machine on humans in the ideas of the authors. But authors seem to suggest that if firms and entrepreneurs continue to invest in automation as a tool to increase productivity than a paradoxical result can arise: the contemporary reduction either of workforce either of the production. Authors suggest to develop technologies that are able to improve the human contribution to the economic production in order to increase both wages and productivity. Authors conclude their article considering the complex set of exogenous elements that can promote the development of technologies that empower the role of humans in the productive system such as for example: labor market institutions, government policies, taxes and research, market competition, corporate strategies.

(Aghion, et al., 2017)analyze the impact of artificial intelligence on economic growth. Authors consider artificial intelligence as the ultimate form of innovation. Artificial intelligence can boost automation especially in the service sector that is in the process of realization of immaterial products. Artificial intelligence is not only able to automate tasks, but it is also capable to create new tasks. The entire process of innovation in the production process of goods and services can be effectively realized with artificial intelligence. Artificial intelligence can participate in the creation of innovation. In the future the entire process of research and development will be realized using artificial intelligence as a tool to find innovations and to create new knowledge that can be used for productive purposes. This new role of artificial intelligence questions the entire theory of the centrality of the human capital as a tool to promote economic growth, since artificial intelligence is going to substitute human capital in all the creative processes either in science and in the professional context. The widespread usage of artificial intelligence in the process of production of innovation and in the active research and development increase the production of knowledge and reduce the participation of human capital in the process of economics growth creating the conditions to disapply the Solow[5] model of economic growth. Artificial intelligence will have an active role in creating knowledge, technology, innovation and in shaping the fundamental orientation of the civilization. Especially the development of "*super-intelligence*"creates the conditions for a generative artificial intelligence that can be successful in the creation of innovations in the context of production of immaterial products and services such as for example in the case of research and development and in the case of innovations. But even if artificial intelligence seems to be able to maintain the promise of new rents and increasing returns for many industries, either in the material and immaterial sectors, there are many uncertainties and doubts about the ability of artificial intelligence to generate a more equal society, due to the fact that the increasing irrelevance of the workforce and the reduction in absolute and relative terms of the percentage of labor income in respect to GDP create the conditions for an increase in the Gini Index and in the generalized inequality. The scenario of a "*super-artificial intelligence*" can not only have a negative impact on the role of human capital but can also in general have a negative impact on innovations. In effect firms can evaluate the investment in research and development and the investment in innovation as too risky and too costly, due to the presence of the competitive innovation created by artificial intelligence. Artificial intelligence can reduce the profitability and rents of innovations due to the velocity and the competition in innovation. The probability for small and medium enterprises and organizations to participate actively with some success in the process of innovation and in the determination of valuable outcome in the sense of research and development will approximate to zero due to the increasing value of the output generated by artificial intelligence applied to innovations. The development of artificial intelligence can create the conditions for a more hierarchical systems in the process of creating knowledge and technology, reducing the possibility of firms, organizations and institutions to have access to innovations, and to compete, due to the degree of sophistication and technological investment necessary to compete with artificial intelligence.

Innovation and green economy. Innovations can have a positive or negative impact for the environmental sustainability. In particular the presence of innovations does not guarantee per se the presence of a green

[5] In the Solow model, in the long run the only possibility to increase the economic growth is based on the development of new technologies, a task that last in the responsibility of the human capital. But due to the development of artificial intelligence it is possible to create new knowledge and technology without human capital, due to the fact that human capital will not have any possibility in competing with artificial intelligence in the process of acquiring and elaboration of new knowledge. Artificial intelligence will reduce the role of human capital in the entire process of production of value added either in the context of manufacture, trough the automation, either in the service sector through the development of technology and innovations. The reduction of the human contribution in the productive system in the industrial sector, in the service sector and in the knowledge creation, has relevant social implication, especially in the creation of a "*useless class*" i.e. a class of workers that has no ways to participate actively in the production of value either in the workforce either in the political realm.

orientation. (Aghion, et al., 2020)afford the question of innovations and green economy. The authors question if there are incentives that create the conditions for a "*clean*" or "*dirty*" innovation. In particular "*clean*" innovation is characterized by the presence of a positive environmental sustainability while "*dirty*" innovation has environmental costs. Authors sustain that socially responsible consumers can create the conditions to increase the level of greener innovations. Firms, to increase their market power, can produce green product based on innovations. Authors analyze data from patents, environmental values, and measures of competition. Authors find that the orientation of consumers in respect to green economy can effectively create the conditions for greener innovations. Consumer buying behavior, and pro-social culture can generate incentives to green innovations.

(Hall & Helmers, 2013) analyzes the relationship between patents and innovation in the context of green related technologies. The authors question what are the motivations that can increase the investment of firms in respect to green oriented technologies. Authors have investigated the methodologies of combining open innovation and patenting. The results of the study are twofold i.e.: firms tend to invest in green patent not only for communicative and advertising purposes and the knowledge that is embedded in green oriented patents can be shared with other firms and organizations that have interest in developing innovation to solve the question of climate change.

Innovations, taxation, and incentives. Taxation can give more incentives to firm for investing in innovations. Public incentives can combine the positive elements in the innovation for the productive system with the absence of positive externalities for the workers. (Acemoglu, et al., 2020)consider the possibility for the US state system to increase the taxation on automation, to createa sufficient amount of technology that can boost the productivity and at the same time create the conditions to preserve jobs. Increasing the taxation on automation, in the mind of the authors, can save jobs, with an increase in employment and a greater compatibility between production and socially optimal outputs.

(Jaffe & Le, 2015)analyze the efficiency of the policies oriented to increase the level of innovation subsidizing research and development. The study is focused on New Zealand. Authors found that firms that receive grants to innovate have higher probabilities to apply for a patent in the sequent years. Firms that have obtain incentives in research and development have a high probability to realize new goods and services. The authors show, that in New Zealand, such as in other countries as for example Japan, Canada and Italy the presence of active public policies financing Research and Development has a positive impact on the introduction of new products and on the creation of new patents.

(Goldberg, et al., 2006) consider the role of Research and Development to promote economic growth and economic development in the context of Europe and Central Asia-ECA. The main difficulty in ECA consists in the missing bridge between the production of knowledge and its implementation in industry, manufacture, and service sector. The translation of innovations in commercial applications is a real problem in the European and Central Asia countries. One of the problems in European and Central Asian countries is the fact that the development of innovation is based on public founding while the participation of private capital is weak offering inefficient resources to the development of the sector.

(Hall, 2019) affords the question of the presence of tax incentives to innovation in various countries. The author discusses the motivation that sustain the introduction of these incentives, their effects on the development of innovation in the industrial and economic system. Three different incentives are analyzed: R&D tax credits, super deduction and reduction in corporate taxes from patents and intellectual property. Author questions the efficiency of the tax subsidies to effectively promote the investment in innovation. The presence of tax incentives is promoted for the fact that the social returns of research and development are higher than private returns.There are positive spillover effects either at a national level either on an international level. Spillovers at an international level are greater for small open economies while are smaller for greater high-income economies such as for example Us, Japan, and Germany. The analytical data suggests that the positive externalities and spillover are always present either at a national and at an international level but the degree of the efficiency of the tax subsidies can change based on different factors such as for example country size, the degree of openness of the economy as a whole and the level of development of the industrial system. SinceResearch and Development has positive externalities the level of investment either in the public sectors either in the private sector tends to be under the social optimal. Data shows that the actual level of investments in research and development is far from the optimal frontiers. Countries, even developed and industrialized country, should increase their level of investment in research and development to pursue the social optimal level. For these reasons, the author suggests that the level of tax subsidies for research and development should be larger. Larger economies should invest more in research and development since their investment has positive international spillover and positive externalities for the global economy. The author also suggeststo develop some kind of international cooperation to reduce the fiscal competition among the promotion of tax subsidies on research and development and either to improve the positive spillovers generated by the economics of innovation and knowledge. The presence of positive externalities and spillovers in the context of international cooperation is

also demonstrated by the productive behavior of multinationals. Multinationals tends to increase the expenditures in research and development in each country in which they operate after having introduced successfully innovation such as patents and intellectual propriety rights.

(Gaessler, et al., 2018) discuss the relevance of tax subsidies to promote the development of investment in patent rights. Authors use the expression "*patent box*" to describe the application of lower corporate taxes on income that is produced by using or own patents. The "*patent box*" as a subsidy to promote patents has been introduced in many countries. But the authors sustain that the presence of patent box has not operated as an incentive to increase the innovation effort of the firms in creating new product and services, but instead has been used by firms and corporations as a tool to relocate business activities in countries with more favorable fiscal legislation. The introduction of a low corporate tax rate on patent related income has focalized the attention of the authors that have tried to evaluate the efficacy of the fiscal policy measure. Authors found that rather than increasing the overall degree of innovation in multinational organizations, these reduction in taxes on patent related income has created a transfer of patent from less efficient fiscal system to fiscal system based on the "*patent box*" subsidy. The patent box has not produced an increase in innovations in the country but has simply increased a sort of free riding behavior of multinational firms and corporations. The authors criticize the presence of "*patent box*" for many reasons: first of all many innovations are realized with inputs that are different from Research and Development direct expenditures; second many firms realize patents to maximize profits and rents and in this case the state subsidize the predatory behavior of the corporation; third the "*patent box*" should help organizations to increase their efforts in the innovation process, but it seems that this incentives have low efficiency in promoting new discovery or a more active pro-innovation firm orientation.

Innovation and Schumpeterian theory.(Aghion, et al., 2014)afford the question of the role of Schumpeterian theory of innovation in respect to other kind of economic growth theory. Authors found that the Schumpeterian theory of innovation can predict better than other theories the complex mechanism of market design, the idea of development of markets, of evolution of firms and the emergence of waves. In effect the Schumpeterian theory of innovation economics can shed lights on the complex process of economic growth, overcoming the limitation of total factor productivity theory and increasing the ability to predict the efficiency of the economic path.

(Aghion, et al., 2016) afford the question of the relation of between the process of creative-destruction and the well-being among workers. Authors consider the impact of turnover on the well-being of workers. The results show that the process of creative destruction applied to the worker well-being tends to increase in the case of job creation and to decrease in the case of job destruction. But job destruction is more affordable in countries and areas that are characterized by the presence of unemployment insurance policies. Individuals that are more forward-looking react with deeper enthusiasm to job creation.

(Aghion, 2017) has tried to re-elaborate the Schumpeterian theory of innovation based of three essential elements: the innovative role of entrepreneurs; the role of economic policies and institutions in shaping incentives; the process of substitution of old technologies with new innovations. The main idea of the article is that the economic growth is based on two forces: creative destruction and the conflict between incumbents and new entrants. Schumpeterian theory can solve some relevant issues of the contemporary economic system such as the secular stagnation, the rice in income inequality and the middle-income trap.

(Aghion & Festré, 2017)analyze the role of Schumpeterian theory either in the sense of economic growth either in the sense of ownership. The authors showthat Schumpeterian theory can be useful to inspire new economic policies to develop research and development issues. To increase economic growth, especially in a Schumpeterian framework, it is important for the government to develop institutions that can promote effectively political and economic development and growth. Three are the elements that can promote a more growth-oriented political economy: the investment in knowledge, liberalized markets, and a reform of public governance. The reform of the public governance seems difficult in the context of institutions for the fact that it requires the definition of the long run strategic interests of the countries. Generally, policy makers have shown a preference for strict shortermism in political economy. (Aghion & Festré, 2017) reject the idea that the solution for the state can be either the welfare state either the minimal state and consider the necessity to find a mediation between these two extremes to realize the conditions of a State that sustain actively the supply side of products and services especially in high innovative sectors. The idea of the authors is that of a sort of Innovative State i.e. a State that invest in the production of innovative goods and services. A kind of state that invest in the economy considering the rates of returns and that can use the financial resources to obtain budget balances.

Innovations and exports. More innovative countries and firms have more probabilities to participate in international commerce. The international projection of firms creates deeper incentives to innovate. In particular (Sin, et al., 2014) have shown that more innovative firms tend to export more in absolute value. But more innovative firms are also able to export to more countries, and, the goods and services that have deeper technological and innovative contents are more requested on the international market. The confrontation with the international market creates incentive to innovate. This is also a sort of implicit suggestion for the policy maker since pushing firms to international commerce, through the increasing level of innovation can effectively

createthe right incentive to innovate. Policy makers that promote incentive for the internationalization of the firms, are also able to pursue the object of the innovation.

Performance of Innovation, intangibles assets and research and development.(Chappell & Jaffe, 2018)analyze the impact of intangible investments on the performance of the firm on an empirical basis. Authors use data from 13.000 firms in the period 2005-2013. The level of investments in intangible assets is positively associated with the firm size. But on the other side extreme level of competitions i.e. too low or too high competition are associated to a lower degree of investments in intangible assets. Intangible assets have a positive impact on firm performance increasinglabor and capital inputs and revenues. Investments in intangible assets are also associated to a greater level of customer satisfaction. But the authors find no evidence of the presence of a positive association between investments in intangible assets and the increasing level of productivity and profitability. This can be considered as a confirmation of the fact that markets that are characterized by competition, in which firms have to increase productivity to gain market shares, are not positively associated to the presence of incentives to invest in intangible assets such as knowledge, innovation and research and development.

(Hall, et al., 2010)in a large survey afford the question of the relation between investment in research and development and the level of firm performance, social return, and economic spillovers. The authors, even controlling the particular role of research and development in the context of investment and the difficulty to determine exactly the costs and the associated revenues, consider the expenditures in R&D has productive of higher rate of returns in respect to other usage of capital. But R&D investments also have depreciation rates even if they change on a sectorial basis and on the degree of competition. In their analysis of the returns of research and development, authors found that the government investment in research and development is less efficient in respect to the private investment in research and development due to the fact that public investment in research and development are devoted to discoveries and technologies that are not entirely computed in the GDP account. Authors try to suggest policies to increase the level of investment in research and development in middle- and low-income countries to create the conditions for large spillovers in these countries, based not only on knowledge transfer but also based on the presence of investments in productive sectors such as for example in the manufacturing sector. But the authors also consider the difficulty to analyze the productive impact of research and development expenditures in the service sector. Research and development expenditures are only a part of the largest set of innovation expenditures.

Innovation and competition. (Aghion, et al., 2014)analyze the impact of innovation on competition. Authors imagine a model in which the technological impact of research and development is marginal and substantially based on step by step. Competition is defined as a condition that holds for firms that are similar in the market in the sense of production, technology, and potential growth. Authors suggest that the competition has a negative effect on the implementation of research and development expenditure especially for that firms that late entrants in a short time horizon. Under the pressure of competition firms can reduce their investments in research and development especially in the absence of a long-term strategy. If the firm is captured by an aggressive competition that its ability to invest successfully in the research and development is low and the firm can assume a shortermist competitive behavior based on the replication of the incumber firms reducing its ability to innovate through R&D. In the end the increasing competition tends to have a concentration effect on the industry composition and tends to create less competitive sectors.

Innovation and inequality. (Aghion, et al., 2019)analyze the relationship between innovation and inequalities in the United States. Authors find that innovation can promote social mobility and top income inequality. Innovation has an impact to increase inequality only of top incomes. Regression analysis shows that innovation is positively connected to social mobility and that the positive relation between innovation and social mobility works especially for new entrants and have low effect for incumbent. States with deeper lobbying activity show a weaker relation between innovation and social mobility. Data suggests the presence of the validity of the Schumpeterian theory of creative destruction in which the possibility to perform social mobility and to access to high income is based essentially on the presence of innovation that is able to drive the economic system toward economic growth.

Innovations, patents, and property rights. (Hall, et al., 2015)afford the question of the development of technology in the presence of patent thickets in UK. Authors present a model to calculate the presence of incentives to create the condition for firms to enter in technological sectors that have technological opportunities. Authors suggest that the presence of patent thickets is associated to an increase in cost of patenting in each technology. Patents thickets operate as an obstacle in the production of technology. Patent thickets have the effect to reduce the degree of innovation in a certain technological area. Patent thickets are built to reduce the level of competition in the development of technology. But the social cost of patent thickets is high, since in the presence of patent thickets the degree of innovation that is generated in a certain economic system tends to be lower that the social optimal. In adjunct, the presence of patent thickets can also have an effect in the reduction of productivity in certain industrial sectors especially for the case in which firms have to

buy multiple patents to produce goods and services. In the end patent thickets can be considered as a conservative and preservative strategy for innovators that wants to reduce the level of innovation in a certain sector to protect their market power, to pursue the objective of rent seeking and to reduce the probability that new entrants realize a strategy based on the Schumpeterian creative-destruction reducing the market share of incumbents.

(Aghion, et al., 2015)analyze the relationship between the presence of patents and propriety rights and the development of a markets oriented to innovation. Authors consider the relationship between the institutional and legislative structure of the market economy and the diffusion of strong or weak patent rights in European countries in the aftermath of the 1992 reforms. The study suggests that the creation of the European unique market has created positive effects, in the sense of innovation, for those countries that had a strong patent rights legislation, while, at the contrary has reduced the ability to innovate in countries with weak patent rights legislation. Industrial sectors characterized by more patents rights had more incentive to develop further innovations, in respect to industrial sectors traditionally characterized by the scarcity of patent rights. The authors have interpreted these results in the light of the Schumpeterian theory of the "*step by step*" innovation. There is a positive relation among competition, patent rights,innovation, and monopolies. Firms that use a deeper patent protection can prolong the rents from the innovation and by this mean that they can have incentives also to reduce competition and develop an orientation towards some form of monopoly. But, this behavior, even if can be considered as profitable for the firms and its ability to exploit the market, is socially depreciable, due to the fact that the degree of innovation generated in this case is under the social optimum.

(Jaffe & Trajtenberg, 1996)analyze the presence of patent citations as a tool to investigate the transfer of knowledge and innovation among institutional and national boundaries. The mechanism of diffusion of knowledge can have an impact for economic growth and development. Authors analyze the distribution of patent quotations. Authors found that patent quotation among the same country are greater than patent quotations at an international level. Patent rights are effectively concentrated at a geographical level. The distribution of patent rights has a geographical distribution since generally firms and human capital that have the necessary skills to introduce innovation that can be recognized through patent rights are in the same area. The geo-localization of firms, in the same sector, in a certain area, increases the probabilities of a certain innovation and a certain patent rights to be cited or used.

(Jaffe, 2000) analyzes the modification in the patent policy and practice in U.S. The author considers that patents are not the only way to preserve innovation. But the diffusion of patent rights has created a situation in which patent are diffused in the public research community. New patents are feasible for innovations that previously were largely unpatentable. The author questions the utility of patents to create profitability in some sector, and he concludes that patents are not necessary to generate returns in R&D industries.

(Aghion, et al., 2018)consider the impact of demand shocks on the decision of firms to innovate. Authors consider data from French market. The presence of a demand shock that increase exports create the condition for the augmenting of innovation among firms. Firms realize patents inresponse to a demand shock guided by export in 3 or 5 years after the shock. But the effect of a demand shock is not only in the sense of the incentive to innovate, it operates also in increasing the level of wages and sales. The response that the firm realize in the sense of innovation is interpreted in the context of endogenous growth. Firms endogenously create innovation to respond to the demand-shock.

Innovation, localization, and internationalization. (Hall, 2011) analyzes the role of the internationalization in respect to research and development spending. The author considers three main questions: the internationalization of the research and development; the factors that have an influence in the process of location of research and development and the evolution of the R&D sector over time. The increasing globalization has reduced the value of the contribution of the national GDP to global GDP for many countries, and the expenditures in research and development has been reduced in absolute and relative term. In this sense many OECD countries the level of investments in R&D appears insufficient in respect of the past even if the global expenditure for research and development is increasing. The relocation of R&D enterprises tends to be more oriented to eastern countries were the spillover effects between research institutes and the manufactory industry is deeper than in other countries. Probably in the context of a global specialization of the research and development the eastern countries will be more prone to apply knowledge to manufacture while the western countries will be more oriented to perform a sort of research-service nexus. But even this juxtaposition between the servitization of western economies and the industrialization of eastern economies can be considered as historically contingent.

Innovation and productivity. (Mohnen & Hall, 2013)analyze the relationship between technological and non-technological innovations on the productivity of the firms. Authors ask if these different typologies of innovations have a differentiated impact on the productivity of the firm. Innovation increase the productivity, performance, and revenues. But not all innovations are technological innovations. In effect there are innovations that are realized in the managerial realm such as for example products, processes, organizational and

marketingimprovements. These innovations are realized not based on technology but based on changes in the organizational structure, operating in the logistic, distributional and in the praxeology of the productive system. But generally technological innovationsand managerialand organizational innovations are strictly associated in the same framework and it can be difficult to distinguish among these features. Technological innovation can suggest organizational innovation but also the reverse is true. We can suppose that while technological innovation has a more then proportional effect on organizational change, the impact of organizational innovation in infer technological innovation is less than proportional. The two typologies of innovations, i.e. technological and non-technological innovations are strictly associated, and it is not possible to distinguish effectively between them. Data and empirical observations suggest that technological and non-technological innovations area complementary goods, but the degree of the association is not clear and can change among sectors and based on size of firms and human capital employed in the managerial task. The presence of technological and non-technological innovation increases the cost of firm to stay in the market. In particular firms have to compete either in technological innovations and either in managerial innovations and this multiple competition can put newcomers out of the market, can increase the uncertainty in the economy and finally can increase the probability of financial failures for incumbents due to explicit and sunk costs to sustain to afford the competition.

(Aghion, et al., 2019) consider the contradiction that characterize the American economy in which while on the one side GDP growth has fallen on the other side firm concentration and profits have risen. The labor's share on national economy in the US economy is declining. Technology has created new markets but only the most efficient firms are able to enter new markets, while less efficient firms have low ability to use the new technologies and methodology of production. Less efficient firms consider more difficult to participate to more developed technological market and by this way these economic organizations innovate less and are less able to contribute actively to GDP. Less efficient firms generally operate also in more competitive markets and the pressure to compete can reduce the resources feasible to perform productive innovation. In effect, coherently with mainstream economics, pure competitive markets are note able to generate knowledge and technology in a way that can optimize the social outcome. Generally competitive markets tend to underperform in the process of creation of knowledge and technology even in respect to monopolies and oligopolies. The question that authors are interested in analyze is based on four different elements that are: a reduction in the labor income share, a reduction in productivity, an increase in the concentration of ownership, and the reduction of job reallocation rates.

(Kanwar & Hall, 2014) analyze the relationship between market value and innovation in the Indian manufacturing industry in the period 2001-2010. Authors find that financial markets evaluate the investment in research and development realized in India with the same metrics of other more developed and industrialized countries such as US. The knowledge and human capital that is realized in the firms that have a positive engagement in research and development, in the case of Indian manufactures, are incorporate in the stock value of the firm.

III. THE ESTIMATED MODEL

We have estimated the sequent model

$$\begin{aligned}\boldsymbol{InnovationIndex}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{AttractiveResearchSystems})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{BusinessAndEnterpreneurship})_{it} + \boldsymbol{b_3}(\boldsymbol{Demography}) \\ &+ \boldsymbol{b_4}(\boldsymbol{EmploymentImpacts})_{it} + \boldsymbol{b_5}(\boldsymbol{FinanceAndSupport})_{it} \\ &+ \boldsymbol{b_6}(\boldsymbol{FirmInvestments})_{it} + \boldsymbol{b_7}(\boldsymbol{GovernanceAndPolicyImplications})_{it} \\ &+ \boldsymbol{b_8}(\boldsymbol{HumanResources})_{it} + \boldsymbol{b_9}(\boldsymbol{InnovationFriendlyEnviroment})_{it} \\ &+ \boldsymbol{b_{10}}(\boldsymbol{Innovators})_{it} + \boldsymbol{b_{11}}(\boldsymbol{IntellectualAssets})_{it} \\ &+ \boldsymbol{b_{12}}(\boldsymbol{PerformanceAndstructureOfTheEconomy})_{it} + \boldsymbol{b_{13}}(\boldsymbol{SalesImpacts})_{it} \\ &+ \boldsymbol{b_{14}}(\boldsymbol{Linkages})\end{aligned}$$

We found the sequent relations in out estimated equations[6]:

- *Business and Entrepreneurship:* negative association. This result is coherent with the idea that increasing in the level of competition among markets leads to lower degree of innovations. The development of business and entrepreneurship is associated to more competitive markets and competitive markets have lower ability to invest in innovations and technology in respect to monopolies and oligopolies. Firms, in competitive markets, tends to be more concentrated in investing to acquire the consumer attention than in investing to generate innovations and technology. Even if in the Schumpeterian theory entrepreneurs are a driving force

[6]These results are realized by summing up the coefficients of the variables associated to each category. The complete results are in the appendix.

for the development and implementation of innovation especially in the sense of creative-destruction, there are limitations that are due to the level of competition: too competitive markets are associated with lower degree of innovation.

- *Performance and Structure of the Economy:* negative association. Innovations tend to operate as a countercyclical solution. In effect in the case of well-performing society, the role of innovations can be marginal, and firms are more concentrated in extracting rents and maximizing profits. Firms can develop more aggressive and competitive behaviors in a well-functioning society trying to monetize the benefits of Gdp growth instead of investing to increase the level of innovations and technology. Especially in the case of big business, in the case of rising markets and well-performing economies, there are incentives to extract rents and exploit workers, consumers, stakeholders and shareholders, instead of investing in innovation and technology.
- *Attractive Research Systems*: positive association. The development of attractive research systems is positively associated to an increase in the innovation index. The innovation index is in a certain sense the result of more efficient and open attractive systems. Generally, more attractive research systems are associated with higher levels of innovation index. Attractive research systems are created as a productive partnership between private and public investment in research and development.
- *Demography:* positive association. More populated countries are positively associated with an increase in the innovation index. This proposition holds for European countries, but it should be tested also in non-European countries to verify its functioning. But with referring to European countries the positive association between innovation index and demography can be better understand considering the fact that more populous countries in general have large public budgets and more tax subsidies to finance innovations and research and development activity.
- *Employment Impacts*: positive association. The positive association is since innovation is an activity that have a relevant impact in the sense of human capital. But, as we argued, this positive relationship between innovation and human capital, can turn negative in the future due to the fact that the development of artificial intelligence creates the condition for a tech-driven innovation in substitution to a human-based innovation. The positive effect between labor variables and innovations can be considered as a contingent relationship that the development of artificial intelligence should turn negative, in the future development of technology.
- *Finance and Support*: positive association. The presence of a financial system that either in a private and public dimension can sustain innovations has effectively a positive impact in the ability of a country to perform well in the sense of the innovation index. Finance and support is either associated to the presence of venture capitalists and business angels that are able to finance innovations either associated to the presence of public programs that finance universities and research institutes actively engaged in the process of creating innovations. The development of institutions, organizations and instruments that can improve financial resources destined to research has a positive impact on the ranking of a country in the sense of the innovation index.
- *Firm Investments:* positive association. Firm investments in innovations is a composite index that considers three elements: R&D and non-R&D investments in innovations and expenditures to increase the ICT skills for employee in the corporation. There is a positive relationship between firm investment and innovation index. The more firms invest in the production of innovations and in empowering employees with hard ICT skills the greater the impact on the innovation index. Private corporate investments in innovations have a country-level impact and are positively associated to an increase in the ranking of the country in the sense of the innovation index.
- *Governance and Policy Framework:* positive association. Governance and policy framework are a complex variable that is based on 4 variables: ease of starting a business, basic school entrepreneurial education and training; government procurement of advanced technology products, rule of law. The ability of a government to increase these variables is associated positively to an increase in the ranking in the innovation index. Simplification, de-regulation, a more accessible public administrative system, the reinforcement of education and training i.e. a government more oriented to sustain innovation is associated to a better performance in the sense of innovation index. Since innovation and in general knowledge is a public good the role of government in offering the right incentives to innovate has a positive role in the development of the economics of innovation.
- *Human Resources*: positive association. The definition of human resources is based on three different measures i.e. the presence of new doctorate graduates, population aged 25-34 with tertiary education, population in the age 25-64 in education and training. An increase in the determination of human resources generate an increase in the ranking of countries in the innovation ranking. But, as suggested for the case of the variable "*demography*" and as reported in the referenced literature it is necessary to recognize that this positive association can turn negative due to the affirmation of artificial intelligence especially in the case of super-artificial intelligence. In effect superintelligence, that is the short form for "*super artificial*

intelligence" will realize many of the activities in the field of research and development and in the field of innovation and technology reducing the ability for human to participate actively in the creative process of generating new knowledge and new technologies. Humans risk to become redundant in the case of the affirmation of super artificial intelligence.

- *Innovation-friendly environment:* positive association. This variable is the sum of two different variables that are "*Broadband penetration among enterprises*" and "*Opportunity-drive entrepreneurship*". These two variables give a measure of the ability of an entrepreneurial system to be sensible to innovations. We can distinguish this variable in two part: a part that in a certain sense has a public and governmental commitment that is the "*Broadband penetration among enterprises*" and a pure private part i.e. "*Opportunity drive entrepreneurship".* Broadband penetration among enterprises can be considered as a sort of public variable for the fact that to create broadband it is necessary the public intervention at least partially, while "*Opportunity-drive entrepreneurships*" can be considered as a private and market based variable for the fact that the reaction of firms in regard to new opportunities that are present in the market and discovered through technologies is based essentially on the presence of a pro-business and pro-risk culture diffused in the economy and in the society as a whole. While the State can in some sense intervene to create more efficient broadband, the affirmation of a culture based on risks and opportunities depends more from the social and human capital that can be only partially be affected from public policies.
- *Innovators*: positive association. The variable "*innovators*" put together a set of variables that consider either innovations in the market either innovations in organizations. Innovation in this case is considered in a widespread meaning, not only as technological innovation but also as marketing and organizational innovation. There is a positive association between innovators and the innovation index. The more firms and organizations increase their ability to innovate in their organizational and technological structure, the more the country has higher results in the sense of innovation index.
- *Intellectual Assets*: positive association. The more a country invests in Intellectual Property Rights-IPR, PCT applications, Trademark applications and Design application, the greater the rank of that country in the sense of the innovation index. This relation seems trivial. But it confirms the idea that technological innovation and research and development improvements are knowledge based, and that the investment in knowledge creates the premises to a growth in the innovation. Even if in the economic theory there is a debate between economists that sustain the necessity of abolish intellectual property rights(Boldrin & Levine, 2002) it is clear that there is a positive relationship among intellectual property rights-IPRs and the degree of innovation.
- *Linkages*: positive association. "*Linkages*" is a variable that includes the ability of creates networks among firms, public and private research institute and that evaluate the ability of firms to co-finance research and development activities. The existence of a positive relationship between linkages and the innovation index shows that there is a network effect in the diffusion of knowledge and innovation and in particular that the deeper the collaboration among research institutes and organizations the higher is the rank of the country in the innovation index.
- *Sales Impact*: positive association. The variable "*Sales impact*" considers some measures of innovation that are the exports of medium and high-tech products, exports of knowledge intensive services, and sales due to innovation activities. The positive association between sales impact and the innovation index shows that innovation is driven also by sales impact. Sales related to high tech, knowledge-based services and innovative activities tend to be higher in countries that have higher degree of innovation index.

The obtained results are tested with panel data with fixed effects, panel data with random effects, weighted least square-WLS and pooled OLS.

IV. CONCLUSIONS

The role of innovations in economics has been recognized has a fundamental force of the economic growth in the Schumpeterian theory. Schumpeter in his analysis of the economic growth has fixed the role of innovation in its connections with institutions, technology, and entrepreneurs. The development of the information science and the creation of the knowledge society and the knowledge economy has confirmed the rightness of the Schumpeterian theory in the recognition of the role of knowledge, innovation and technology and entrepreneurship in the process of economic growth. The affirmation of industry 4.0 has created a particular attention in respect to the ability of countries, firms, organizations and institutions to innovate. The presence of a competitive scenario among countries in controlling technological innovations, especially in the sense of artificial intelligence, big data, machine learning and internet of things, has created the conditions for a deeper attention for the role of innovation.

In this article we have analyzed the determinants of the Innovation Index using data from the European Innovation Scoreboard for 36 countries in the period 2010-2019. We found that the ability to innovate is negatively associated with "*Business and Entrepreneurship"* and "*Performance and Structure of the*

Economy". The ability to innovate is positively associated to "*Attractive Research Systems*", "*Demography*", "*Employment Impacts*", "*Finance and Support*", "*Firm Investments*", "*Governance and Policy Framework*", "*Human Resources*", "*Innovation-friendly Environment*", "*Innovators*", "*Intellectual Assets*", "*Linkages*", "*Sales Impact*".

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Appendix

We have estimated the sequent equation

$$\begin{aligned}\boldsymbol{InnovationIndex}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{AttractiveResearchSystems})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{BusinessAndEnterpreneurship})_{it} + \boldsymbol{b_3}(\boldsymbol{Demography}) \\ &+ \boldsymbol{b_4}(\boldsymbol{EmploymentImpacts})_{it} + \boldsymbol{b_5}(\boldsymbol{FinanceAndSupport})_{it} \\ &+ \boldsymbol{b_6}(\boldsymbol{FirmInvestments})_{it} + \boldsymbol{b_7}(\boldsymbol{GovernanceAndPolicyImplications})_{it} \\ &+ \boldsymbol{b_8}(\boldsymbol{HumanResources})_{it} + \boldsymbol{b_9}(\boldsymbol{InnovationFriendlyEnviroment})_{it} \\ &+ \boldsymbol{b_{10}}(\boldsymbol{Innovators})_{it} + \boldsymbol{b_{11}}(\boldsymbol{IntellectualAssets})_{it} \\ &+ \boldsymbol{b_{12}}(\boldsymbol{PerformanceAndstructureOfTheEconomy})_{it} + \boldsymbol{b_{13}}(\boldsymbol{SalesImpacts})_{it} \\ &+ \boldsymbol{b_{14}}(\boldsymbol{linkages})\end{aligned}$$

Where

$$\begin{aligned}\boldsymbol{AttractiveReasearchSystem}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{ForeignDoctoreStudents})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{InnovationFriendlyEnvironment})_{it} + \boldsymbol{b_3}(\boldsymbol{InternationalCoPublication})_{it} \\ &+ \boldsymbol{b_4}(\boldsymbol{MostCitedPublication})_{it}\end{aligned}$$

$$\boldsymbol{BusinessAndEnterpreneurship}_{it} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{BuyerSophistication})_{it}$$

$$\boldsymbol{Demography}_{it} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{AverageAnnualPopulationGrowht})_{it}$$

$$\begin{aligned}\boldsymbol{EmploymentImpacts}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{EmploymentFastGrowingEnterprisesOfInnovativeSectors})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{EmploymentImpacts})_{it} \\ &+ \boldsymbol{b_3}(\boldsymbol{EmploymentMHTManufacturingfKISServices})_{it} \\ &+ \boldsymbol{b_4}(\boldsymbol{EmploymentShareServices})_{it}\end{aligned}$$

$$\begin{aligned}\boldsymbol{FinanceAndSupport}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{FinanceAndSupport})_{it} + \boldsymbol{b_2}(\boldsymbol{R\&DExpenditurePublicSector})_{it} \\ &+ \boldsymbol{b_3}(\boldsymbol{VentureCapital})_{it}\end{aligned}$$

$$\begin{aligned}\boldsymbol{FirmInvestments}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{NonR\&D}Innovation Expenditure)_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{R\&D}ExpenditureBusinessSector)_{it} \\ &+ \boldsymbol{b_3}(\boldsymbol{EnterpriseProvidingICTTraining})_{it}\end{aligned}$$

$$GovernanceAndPolicyImplications_{it} = a_1 + b_1(BasicSchoolEnterpreneurialEducationAndTraining)_{it} + b_2(EaseOfStartingABusiness)_{it} + b_3(GovernmentProcurementOfAdvancedTechnologyProdcuts)_{it} + b_4(RuleOfLaw)_{it}$$

$$HumanResources_{it} = a_1 + b_1(HumanResources)_{it} + b_2(LifelongLearning)_{it} + b_3(NewDoctorateGraduates)_{it} + b_4(TertiaryEducation)_{it}$$

$$InnovationFriendlyEnviroment_{it} = a_1 + b_1(OpportunityDrivenEntrepreneurship)_{it}$$

$$Innovators_{it} = a_1 + b_1(Innovators)_{it} + b_2(MarketingOrOrganisationalInnovators)_{it} + b_3(ProductOrProcessInnovators)_{it}$$

$$IntellectualAsset_{it} = a_1 + b_1(DesignApplication)_{it} + b_2(TrademarkApplications)_{it}$$

$$Linkages_{it} = a_1 + b_1(Linkages)_{it}$$

$$PerformanceAndstructureOfTheEconomy_{it} = a_1 + b_1(AverageAnnualGDPGrowht)_{it} + b_2(GdpPercapita)_{it} + b_3(ShareHighAndMediumHighTechManufacturing)_{it} + b_4(ShareKnowledgeIntesiveServices)_{it}$$

$$SalesImpacts_{it} = a_1 + b_1(InnovativeSalesShare)_{it} + b_2(KnowledgeIntensiveServicesExports)_{it} + b_3(MediumAndHighTechProductExports)_{it}$$

Summing up the complete set of variables and equations we have that:

$$\begin{aligned} InnovationIndex_{it} = {} & a_1 + b_1(AverageAnnualGDPGrowth)_{it} \\ & + b_2(AverageAnnualPopulationGrowth)_{it} \\ & + b_3(BasicSchoolEntrepreneurialEducationAndTraining)_{it} \\ & + b_4(BuyerSophistication)_{it} + b_5(DesignApplications)_{it} \\ & + b_6(EaseOfStartingABusiness)_{it} \\ & + b_7(EmploymentFasGrowingEnterprisesOfInnovativeSectors)_{it} \\ & + b_8(EmploymentImpacts)_{it} \\ & + b_9(EmploymentMHTManufacturingKISServices)_{it} \\ & + b_{10}(EmploymentShareServices)_{it} \\ & + b_{11}(EnterprisesProvidingICTTraining)_{it} + b_{12}(FinanceAndSupport)_{it} \\ & + b_{13}(ForeignDoctorateStudents)_{it} + b_{14}(GDPPerCapita)_{it} \\ & + b_{15}(GovernmentProcurementOfAdvancedTechnologyProducts)_{it} \\ & + b_{16}(HumanResources)_{it} + b_{17}(InnovationFriendlyEnvironment)_{it} \\ & + b_{18}(InnovativeSalesShare)_{it} + b_{19}(Innovators)_{it} \\ & + b_{20}(InternationalCoPublications)_{it} \\ & + b_{21}(KnowledgeIntensiveServicesExports)_{it} + b_{22}(LifelongLearning)_{it} \\ & + b_{23}(Linkages)_{it} + b_{24}(MarketingOrOrganisationalInnovators)_{it} \\ & + b_{25}(MediumAndHighTechProductExports)_{it} \\ & + b_{26}(MostCitedPublications)_{it} + b_{27}(NewDoctorateGraduates)_{it} \\ & + b_{28}(NonR\&DInnovationExpenditure)_{it} \\ & + b_{29}(OpportunityDrivenEntrepreneurship)_{it} \\ & + b_{30}(ProductOrProcessInnovators)_{it} + b_{31}(R\&DExpenditureBusinessSector)_{it} \\ & + b_{32}(R\&DExpenditurePublicSector)_{it} + b_{33}(RuleOfLaw)_{it} \\ & + b_{34}(ShareHigh\&MediumHighTechManufacturing)_{it} \\ & + b_{35}(ShareKnowledgeIntensiveServices)_{it} + b_{36}(TertiaryEducation)_{it} \\ & + b_{37}(TrademarkApplications)_{it} + b_{38}(VentureCapital)_{it} \end{aligned}$$

	Effetti fissi		Effetti casuali		WLS		POOLED OLS	
	Coefficiente	p-value	Coefficiente	p-value	Coefficiente	p-value	Coefficiente	p-value

Costant	−2,17928	***	-0,562372		0,00486826		0,063966	
Average annual GDP growth (SD)	−1,19816	***	-1,13915	***	−0,422497	***	−1,06391	***
Average annual population growth (SD)	2,03918	***	2,08146	***	0,786589	***	1,92335	***
Basic-school entrepreneurial education and training (SD)	−0,0419889	***	-0,0331069	***	−0,0267497	***	−0,0326170	***
Buyer sophistication (SD)	−1,85943	***	-1,97674	***	−0,699262		−2,34432	***
Design applications	0,0276894	***	0,0289058	***	0,024042	***	0,0214377	***
Ease of starting a business (SD)	0,117228	***	0,116544	***	0,028485		0,133672	***
Employment fast-growing enterprises of innovative sectors	0,0187298	**	0,0342412	***	0,0375007	***	0,0372882	***
Employment impacts	0,0369233	***	0,00815914		−6,76729e-05		−0,000253758	
Employment MHT manufacturing KIS services	0,0201017	**	0,0243814	***	0,0378752	***	0,0279663	***
Employment share Services (SD)	−0,0655159	**	-0,0631523	**	−0,0376972	***	−0,0776765	***
Enterprises providing ICT training	0,030054	***	0,0317992	***	0,0276966	***	0,0291461	***
Finance and support	0,284812	***	0,28037	***	0,253255	***	0,268938	***
Foreign doctoratestudents	0,0197806	***	0,0189649	***	0,0130854	***	0,0160024	***
GDP per capita (Thousands of €) (SD)	−0,125553	***	-0,126187	***	−0,0846785	***	−0,133624	***
Government procurement of advanced technology products (SD)	1,08044	***	1,08996	***	1,12109	***	1,11615	***
Human resources	0,266844	***	0,28402	***	0,247317	***	0,280434	***
Innovation-friendlyenvironment	0,047217	***	0,0460854	***	0,0397368	***	0,0423361	***
Innovative sales share	0,0444042	***	0,0460175	***	0,0492324	***	0,0422846	***
Innovators	0,0325938	***	0,0326957	***	0,0389328	***	0,0215726	***
International co-publications	0,0268653	***	0,0281088	***	0,0177182	***	0,0203886	***
Knowledge-intensive services exports	0,0360219	***	0,0374153	***	0,0532049	***	0,04916	***
Lifelong learning	−0,0661176	***	-0,0693548	***	−0,0415840	***	−0,0582537	***
Linkages	0,0994125	***	0,0987227	***	0,105714	***	0,0989424	***
Marketing or organisationalinnovators	0,0764841	***	0,0820469	***	0,0852866	***	0,10131	***
Medium and high-tech product exports	0,0426375	***	0,0420376	***	0,0442615	***	0,0436545	***
Most-citedpublications	0,0751124	***	0,0752823	***	0,0639822	***	0,0639767	***
New doctorategraduates	−0,0632544	***	-0,0699987	***	−0,0583269	***	−0,0639756	***
Non-R&D innovation expenditure	0,0272702	***	0,0275912	***	0,0285756	***	0,0310962	***
Opportunity-driven entrepreneurship	0,0113935	**	0,0111851	**	0,00896341	***	0,0111472	**
Product or process innovators	0,0583583	***	0,0543592	***	0,036026	***	0,0513649	***
R&D expenditure business sector	0,0599548	***	0,0585928	***	0,0590798	***	0,0599882	***
R&D expenditure public sector	−0,125668	***	-0,12232	***	−0,102572	***	−0,115653	***
Rule of law (SD)	0,11966	***	0,117248	***	0,0914632	***	0,116038	***

Share High and Medium high-tech manufacturing (SD)	−0,0797259	***	-0,0772782	***	−0,0452303	***	−0,0756505	***
Share Knowledge-intensive services (%) (SD)	0,156208	***	0,159138	***	0,098203	***	0,191785	***
Tertiary education	−0,0729547	***	-0,075494	***	−0,0578765	***	−0,0714692	***
Trademark applications	0,0581888	***	0,0572992	***	0,0504707	***	0,0563467	***
Venture capital	−0,0779251	***	-0,0761992	***	−0,0646288	***	−0,0702724	***

LEGEND	
Averageannual GDP growth	A2
Averageannualpopulation growth	A3
Basic-school entrepreneurial education and training	A4
Buyer sophistication	A6
Design applications	A7
Ease of starting a business	A8
Employment fast-growing enterprises of innovative sectors	A9
Employment impacts	A10
Employment MHT manufacturing KIS services	A11
Employment share Services	A13
Enterprises providing ICT training	A15
Finance and support	A17
Foreign doctoratestudents	A19
GDP per capita (Thousands of €)	A21
Government procurement of advanced technology products	A22
Human resources	A23
Innovation-friendlyenvironment	A25
Innovative sales share	A26
Innovators	A28
International co-publications	A30
Knowledge-intensive services exports	A31
Lifelong learning	A32
Linkages	A33
Marketing or organisationalinnovators	A34
Medium and high-tech product exports	A35
Most-citedpublications	A36
New doctorategraduates	A37
Non-R&D innovation expenditure	A38
Opportunity-driven entrepreneurship	A39

Product or process innovators	A44
R&D expenditure business sector	A46
R&D expenditure public sector	A47
Rule of law	A48
Share High and Medium high-tech manufacturing	A50
Share Knowledge-intensive services (%)	A51
Tertiary education	A53
Trademark applications	A56
Venture capital	A59

Panel data FixedEffects

357 observations. Cross section: 36 unities

Times Series: min 8, max 10

Dependent Variable: Innovation Index

	Coefficient	*Std. Error*	*t*	*p-value*	
const	−2,17928	0,775652	−2,810	0,0053	***
A2	−1,19816	0,203467	−5,889	<0,0001	***
A3	2,03918	0,372191	5,479	<0,0001	***
A4	−0,0419889	0,0121726	−3,449	0,0006	***
A6	−1,85943	0,633629	−2,935	0,0036	***
A7	0,0276894	0,00612922	4,518	<0,0001	***
A8	0,117228	0,0259260	4,522	<0,0001	***
A9	0,0187298	0,00892660	2,098	0,0368	**
A10	0,0369233	0,0130589	2,827	0,0050	***
A11	0,0201017	0,0100623	1,998	0,0467	**
A13	−0,0655159	0,0298588	−2,194	0,0290	**
A15	0,0300540	0,00416586	7,214	<0,0001	***
A17	0,284812	0,0227204	12,54	<0,0001	***
A19	0,0197806	0,00466734	4,238	<0,0001	***
A21	−0,125553	0,0337975	−3,715	0,0002	***
A22	1,08044	0,0239776	45,06	<0,0001	***
A23	0,266844	0,0272090	9,807	<0,0001	***
A25	0,0472170	0,00580942	8,128	<0,0001	***
A26	0,0444042	0,00543778	8,166	<0,0001	***
A28	0,0325938	0,0108920	2,992	0,0030	***
A30	0,0268653	0,00543273	4,945	<0,0001	***
A31	0,0360219	0,0110750	3,253	0,0013	***
A32	−0,0661176	0,00867238	−7,624	<0,0001	***
A33	0,0994125	0,0124810	7,965	<0,0001	***
A34	0,0764841	0,0112339	6,808	<0,0001	***
A35	0,0426375	0,00896658	4,755	<0,0001	***
A36	0,0751124	0,0113339	6,627	<0,0001	***
A37	−0,0632544	0,0103484	−6,112	<0,0001	***
A38	0,0272702	0,00350955	7,770	<0,0001	***
A39	0,0113935	0,00540266	2,109	0,0358	**
A44	0,0583583	0,0102065	5,718	<0,0001	***
A46	0,0599548	0,00883138	6,789	<0,0001	***
A47	−0,125668	0,0149623	−8,399	<0,0001	***

A48	0,119660	0,0177151	6,755	<0,0001	***
A50	−0,0797259	0,0170120	−4,686	<0,0001	***
A51	0,156208	0,0331370	4,714	<0,0001	***
A53	−0,0729547	0,00855642	−8,526	<0,0001	***
A56	0,0581888	0,00659530	8,823	<0,0001	***
A59	−0,0779251	0,00870235	−8,954	<0,0001	***

Mean dependent variable	79,32081	*MSD dependent variable*	61,45036
Residual Sum of Squares	1101,497	*Regression S.E.*	1,972870
R-squared LSDV	0,999181	*Intra-Group R-squared*	0,998468
LSDV F(73, 283)	4727,409	*P-value(F)*	0,000000
Log-likelihood	−707,6751	*Akaike criterion*	1563,350
Schwarz criterion	1850,303	*Hannan-Quinn*	1677,484
rho	0,131614	*Durbin-Watson*	1,577791

Joint regressor test
Test Statistics: F(38, 283) = 4854,2
p-value = P(F(38, 283) > 4854,2) = 0
Test for the difference of the group intercepts -
Null hypothesis: groups have a common intercept
Test Statistics: F(35, 283) = 3,55625
p-value = P(F(35, 283) > 3,55625) = 1,62853e-009

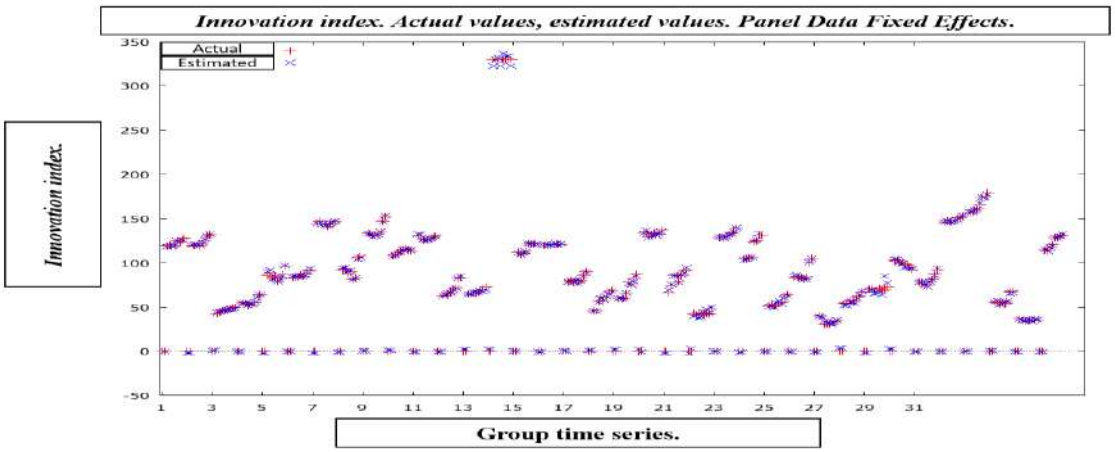

Figure 2.Innovation index.Actual values and estimated values. Panel data fixed effects.

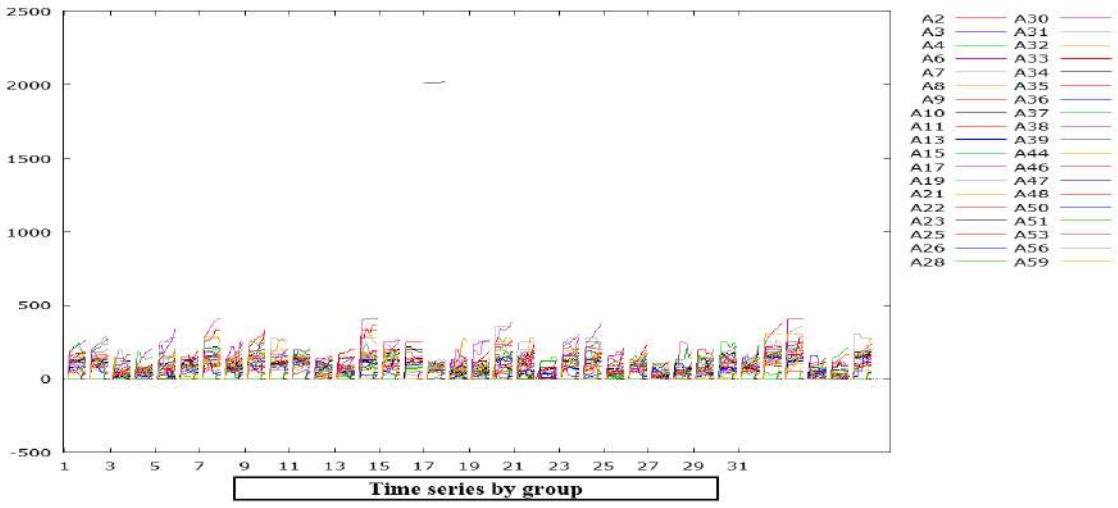

Figure 3. Time series by group.

Panel Data Random Effects

357 observations. Nerlove

Cross Sections: 36 unities.

Time series: min. 8, max 10

Dependent variable: Innovation Index

	Coefficient	*Std. Error*	*z*	*p-value*	
const	-0,562372	2,24498	-0,2505	0,8022	
A2	-1,13915	0,192849	-5,907	<0,0001	***
A3	2,08146	0,354785	5,867	<0,0001	***
A4	-0,0331069	0,0110896	-2,985	0,0028	***
A6	-1,97674	0,602943	-3,278	0,0010	***
A7	0,0289058	0,00582313	4,964	<0,0001	***
A8	0,116544	0,0247390	4,711	<0,0001	***
A9	0,0342412	0,00614869	5,569	<0,0001	***
A10	0,00815914	0,00600640	1,358	0,1743	
A11	0,0243814	0,00945065	2,580	0,0099	***
A13	-0,0631523	0,0284391	-2,221	0,0264	**
A15	0,0317992	0,00390943	8,134	<0,0001	***
A17	0,280370	0,0215901	12,99	<0,0001	***
A19	0,0189649	0,00443554	4,276	<0,0001	***
A21	-0,126187	0,0322503	-3,913	<0,0001	***
A22	1,08996	0,0225697	48,29	<0,0001	***
A23	0,284020	0,0251063	11,31	<0,0001	***
A25	0,0460854	0,00552059	8,348	<0,0001	***
A26	0,0460175	0,00514941	8,936	<0,0001	***
A28	0,0326957	0,0103690	3,153	0,0016	***
A30	0,0281088	0,00515758	5,450	<0,0001	***
A31	0,0374153	0,0105311	3,553	0,0004	***
A32	-0,0693548	0,00816703	-8,492	<0,0001	***
A33	0,0987227	0,0118901	8,303	<0,0001	***
A34	0,0820469	0,0105037	7,811	<0,0001	***
A35	0,0420376	0,00854069	4,922	<0,0001	***
A36	0,0752823	0,0108053	6,967	<0,0001	***
A37	-0,0699987	0,00952054	-7,352	<0,0001	***
A38	0,0275912	0,00334394	8,251	<0,0001	***
A39	0,0111851	0,00514961	2,172	0,0299	**
A44	0,0543592	0,00960408	5,660	<0,0001	***
A46	0,0585928	0,00840166	6,974	<0,0001	***
A47	-0,122320	0,0142058	-8,611	<0,0001	***
A48	0,117248	0,0168494	6,959	<0,0001	***
A50	-0,0772782	0,0161924	-4,772	<0,0001	***
A51	0,159138	0,0316015	5,036	<0,0001	***
A53	-0,0754940	0,00809614	-9,325	<0,0001	***
A56	0,0572992	0,00627831	9,127	<0,0001	***
A59	-0,0761992	0,00826974	-9,214	<0,0001	***

Mean dependent variable	79,32081	*MSDdependent variable*	61,45036
Residual Sum of Squares	4728,622	*Regression S.E.*	3,850100
Log-likelihood	-967,7432	*Akaike Criterion*	2013,486
Schwarz criterion	2164,718	*Hannan-Quinn*	2073,638
rho	0,131614	*Durbin-Watson*	1,577791

Variance 'between' = 152,747

Variance 'within' = 3,08542
theta medio = 0,954887
Joint test on regressors-
Asymptotic test statistics: Chi-square(38) = 202807
p-value = 0
Test Breusch-Pagan -
Null hypothesis: variance of the error specific to the unit= 0
Asymptotic test statistics: Chi-squared(1) = 28,2121
p-value = 1,08723e-007
Hausman - Test
Null hypothesis: GLS estimates are consistent
Asymptotic test statistics: Chi-squared(35) = 8,48997
p-value = 0,999999

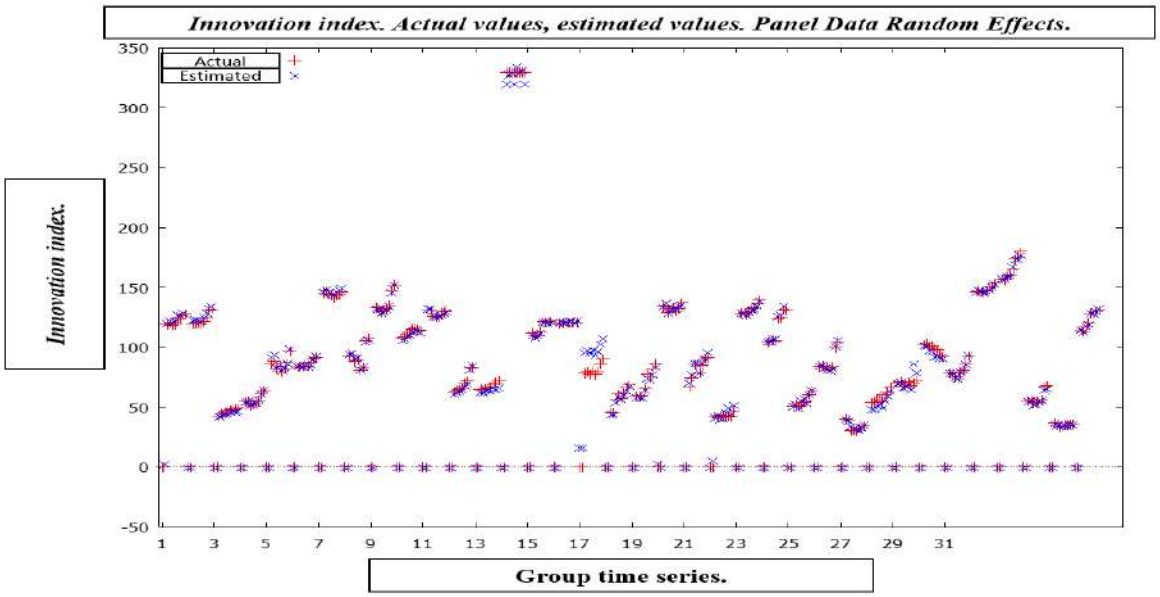

Figure 4. Prediction of Innovation Index. Panel Data wit Random Effects.

WLS					
357 observations					
Cross Section: 36 units					
Dependent Variable: Innovation Index					
Weights based on variances of errors per unit					
	Coefficient	*Std. Error*	*t*	*p-value*	
const	0,00486826	0,114431	0,04254	0,9661	
A2	−0,422497	0,126331	−3,344	0,0009	***
A3	0,786589	0,290401	2,709	0,0071	***
A4	−0,0267497	0,00409047	−6,540	<0,0001	***
A6	−0,699262	0,452516	−1,545	0,1233	
A7	0,0240420	0,00346417	6,940	<0,0001	***
A8	0,0284850	0,0229310	1,242	0,2151	
A9	0,0375007	0,00270309	13,87	<0,0001	***
A10	−6,76729e-05	0,000157131	−0,4307	0,6670	
A11	0,0378752	0,00506677	7,475	<0,0001	***
A13	−0,0376972	0,0143680	−2,624	0,0091	***
A15	0,0276966	0,00160939	17,21	<0,0001	***
A17	0,253255	0,0115290	21,97	<0,0001	***
A19	0,0130854	0,00178937	7,313	<0,0001	***

A21	−0,0846785	0,0232279	−3,646	0,0003	***
A22	1,12109	0,0146556	76,50	<0,0001	***
A23	0,247317	0,0128364	19,27	<0,0001	***
A25	0,0397368	0,00252457	15,74	<0,0001	***
A26	0,0492324	0,00257715	19,10	<0,0001	***
A28	0,0389328	0,00514091	7,573	<0,0001	***
A30	0,0177182	0,00230169	7,698	<0,0001	***
A31	0,0532049	0,00378367	14,06	<0,0001	***
A32	−0,0415840	0,00384863	−10,80	<0,0001	***
A33	0,105714	0,00577350	18,31	<0,0001	***
A34	0,0852866	0,00531669	16,04	<0,0001	***
A35	0,0442615	0,00407142	10,87	<0,0001	***
A36	0,0639822	0,00483222	13,24	<0,0001	***
A37	−0,0583269	0,00440386	−13,24	<0,0001	***
A38	0,0285756	0,00158915	17,98	<0,0001	***
A39	0,00896341	0,00270549	3,313	0,0010	***
A44	0,0360260	0,00462755	7,785	<0,0001	***
A46	0,0590798	0,00425454	13,89	<0,0001	***
A47	−0,102572	0,00804462	−12,75	<0,0001	***
A48	0,0914632	0,00833766	10,97	<0,0001	***
A50	−0,0452303	0,0100693	−4,492	<0,0001	***
A51	0,0982030	0,0205984	4,768	<0,0001	***
A53	−0,0578765	0,00432945	−13,37	<0,0001	***
A56	0,0504707	0,00368629	13,69	<0,0001	***
A59	−0,0646288	0,00432377	−14,95	<0,0001	***

Statistics based on weighted data:

Residual Sum of Squares	271,4501	*Regression S.E.*	0,923914
R-square	0,999655	*R-squared correct*	0,999614
F(38, 318)	24258,45	*P-value(F)*	0,000000
Log-likelihood	−457,6597	*Akaike Criterion*	993,3193
Schwarz Criterion	1144,551	*Hannan-Quinn*	1053,471

Statistics based on original data:

Mean Dependent Variabl	79,32081	*S.D.Dependent Variable*	61,45036
Residual Sum of Squares	1906,107	*Regression S.E.*	2,448274

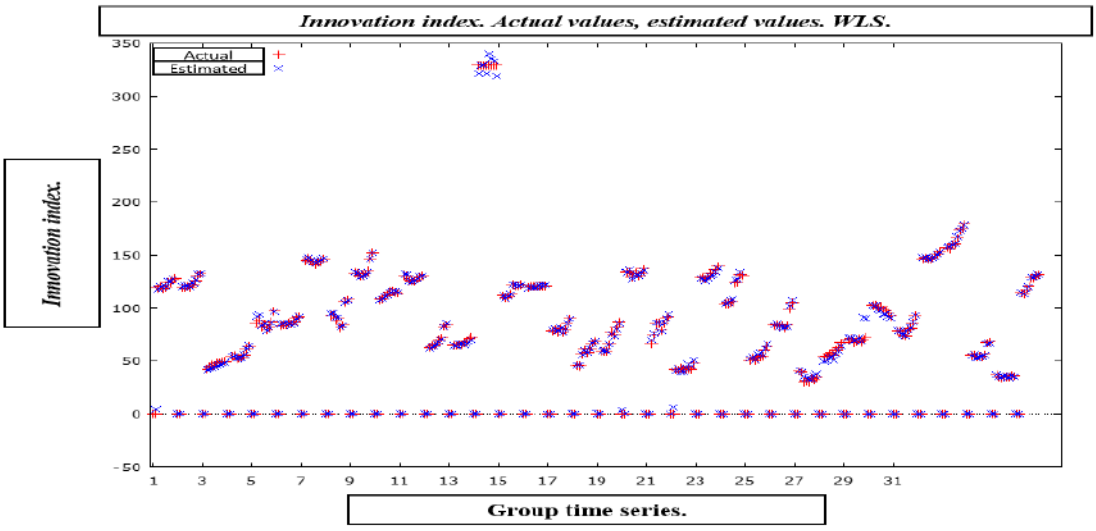

Figure 5. Prediction with WLS.

Pooled OLS					
357 observations. Cross Section: 36 units					
Time Series: min. 8, max 10					
Dependent Variable: Innovation Index					
	Coefficient	*Std.Error*	*t*	*p-value*	
const	0,0639660	0,258673	0,2473	0,8048	
A2	−1,06391	0,216380	−4,917	<0,0001	***
A3	1,92335	0,398853	4,822	<0,0001	***
A4	−0,0326170	0,00791473	−4,121	<0,0001	***
A6	−2,34432	0,657386	−3,566	0,0004	***
A7	0,0214377	0,00517876	4,140	<0,0001	***
A8	0,133672	0,0278240	4,804	<0,0001	***
A9	0,0372882	0,00440145	8,472	<0,0001	***
A10	−0,000253758	0,000456651	−0,5557	0,5788	
A11	0,0279663	0,00868703	3,219	0,0014	***
A13	−0,0776765	0,0234686	−3,310	0,0010	***
A15	0,0291461	0,00275366	10,58	<0,0001	***
A17	0,268938	0,0185738	14,48	<0,0001	***
A19	0,0160024	0,00336941	4,749	<0,0001	***
A21	−0,133624	0,0359531	−3,717	0,0002	***
A22	1,11615	0,0175940	63,44	<0,0001	***
A23	0,280434	0,0217344	12,90	<0,0001	***
A25	0,0423361	0,00465955	9,086	<0,0001	***
A26	0,0422846	0,00486856	8,685	<0,0001	***
A28	0,0215726	0,00702898	3,069	0,0023	***
A30	0,0203886	0,00464419	4,390	<0,0001	***
A31	0,0491600	0,00730995	6,725	<0,0001	***
A32	−0,0582537	0,00654483	−8,901	<0,0001	***
A33	0,0989424	0,0101120	9,785	<0,0001	***
A34	0,101310	0,00871599	11,62	<0,0001	***
A35	0,0436545	0,00705561	6,187	<0,0001	***
A36	0,0639767	0,00967666	6,611	<0,0001	***
A37	−0,0639756	0,00764047	−8,373	<0,0001	***
A38	0,0310962	0,00293149	10,61	<0,0001	***

A39	0,0111472	0,00455618	2,447	0,0150	**
A44	0,0513649	0,00765162	6,713	<0,0001	***
A46	0,0599882	0,00709572	8,454	<0,0001	***
A47	−0,115653	0,0123259	−9,383	<0,0001	***
A48	0,116038	0,0134194	8,647	<0,0001	***
A50	−0,0756505	0,0146826	−5,152	<0,0001	***
A51	0,191785	0,0351030	5,463	<0,0001	***
A53	−0,0714692	0,00696503	−10,26	<0,0001	***
A56	0,0563467	0,00568141	9,918	<0,0001	***
A59	−0,0702724	0,00723564	−9,712	<0,0001	***

Media var. dependente	79,32081	SQM var. dependente	61,45036
SSR	1585,955	Regression S.E.	2,233222
R-squared	0,998820	R-squared correct	0,998679
F(38, 318)	7084,982	P-value(F)	0,000000
Log-likelihood	−772,7414	Akaike Criterion	1623,483
Schwarz Criterion	1774,715	Hannan-Quinn	1683,634
rho	0,358082	Durbin-Watson	1,231206

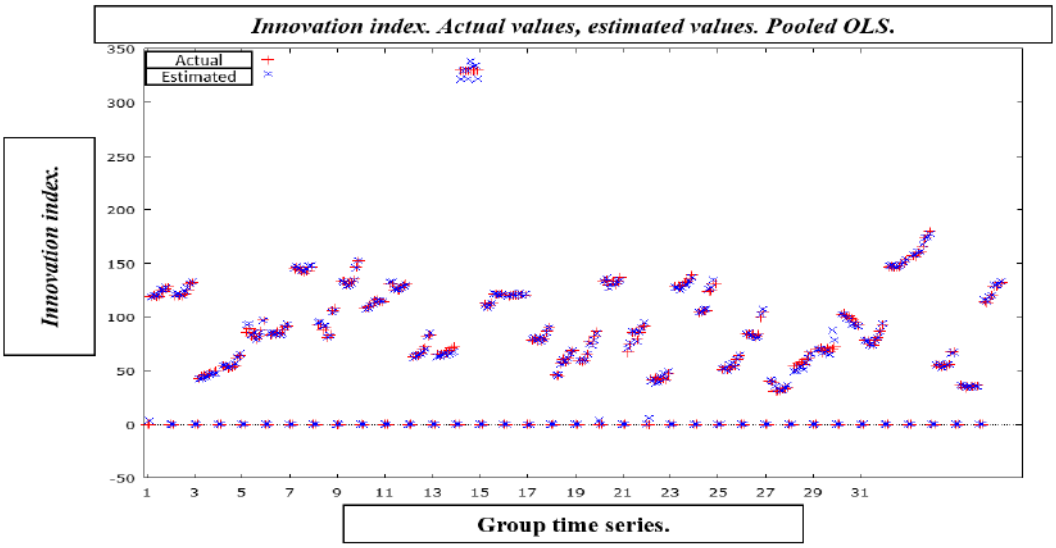

Figure 6.Prediction model pooled OLS.

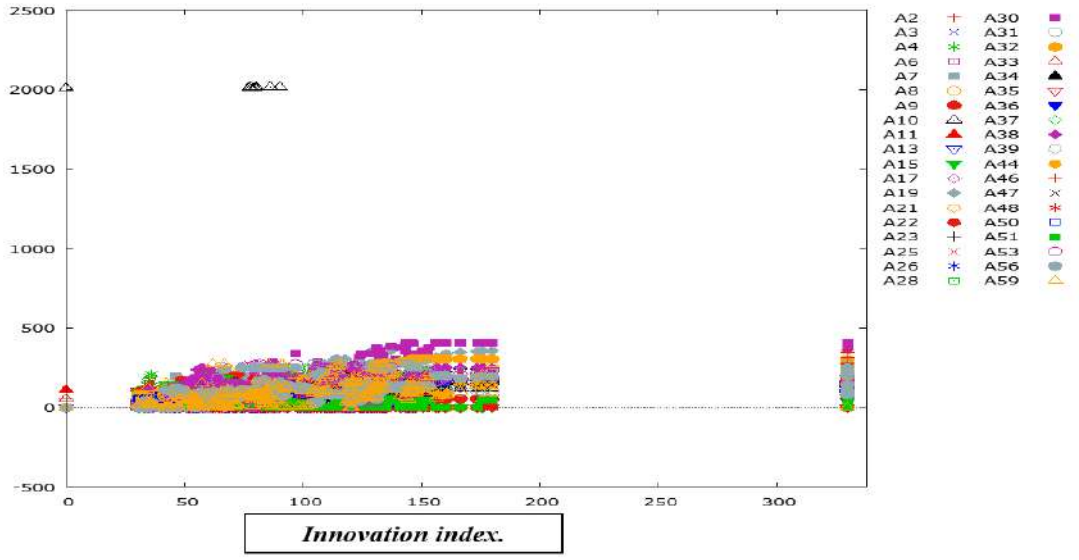

Figure 7. Scatter plot.

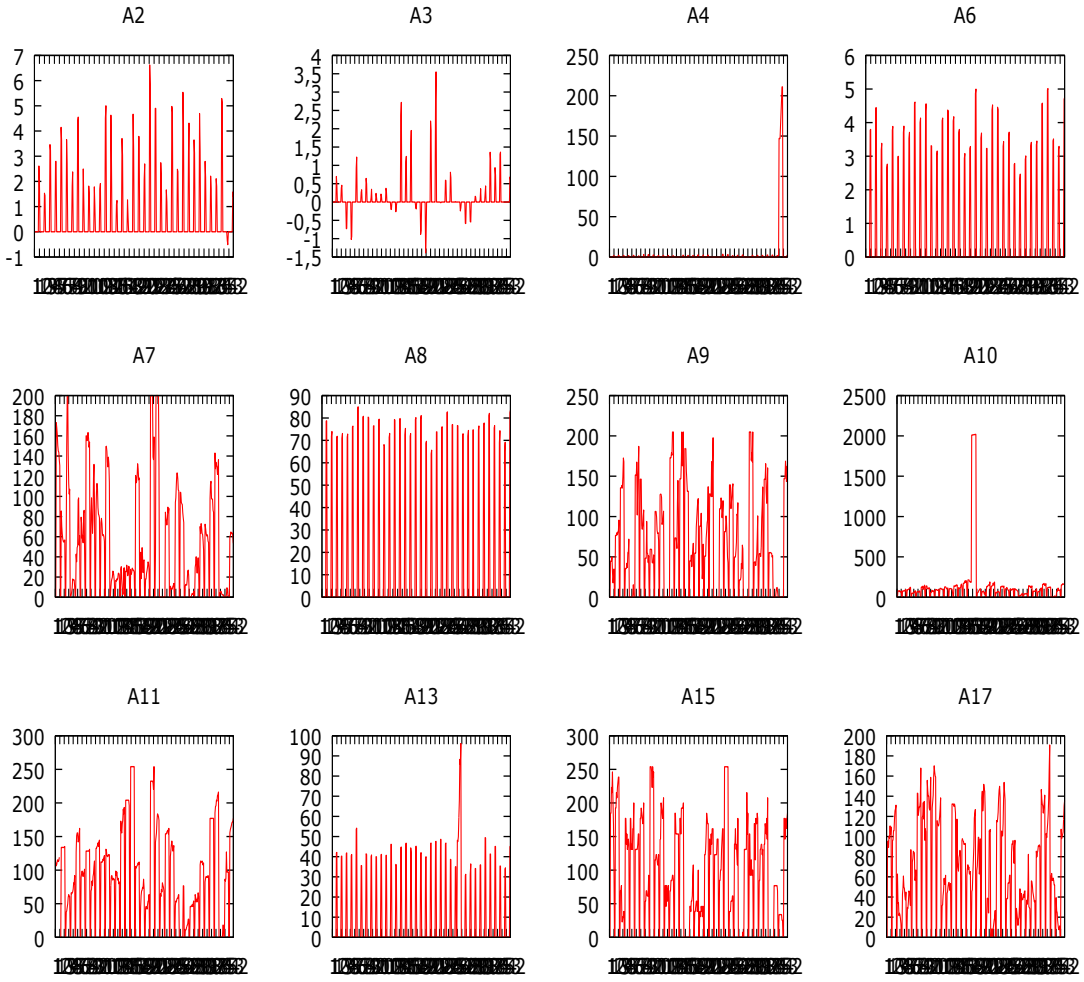

Figure 8. Time series.

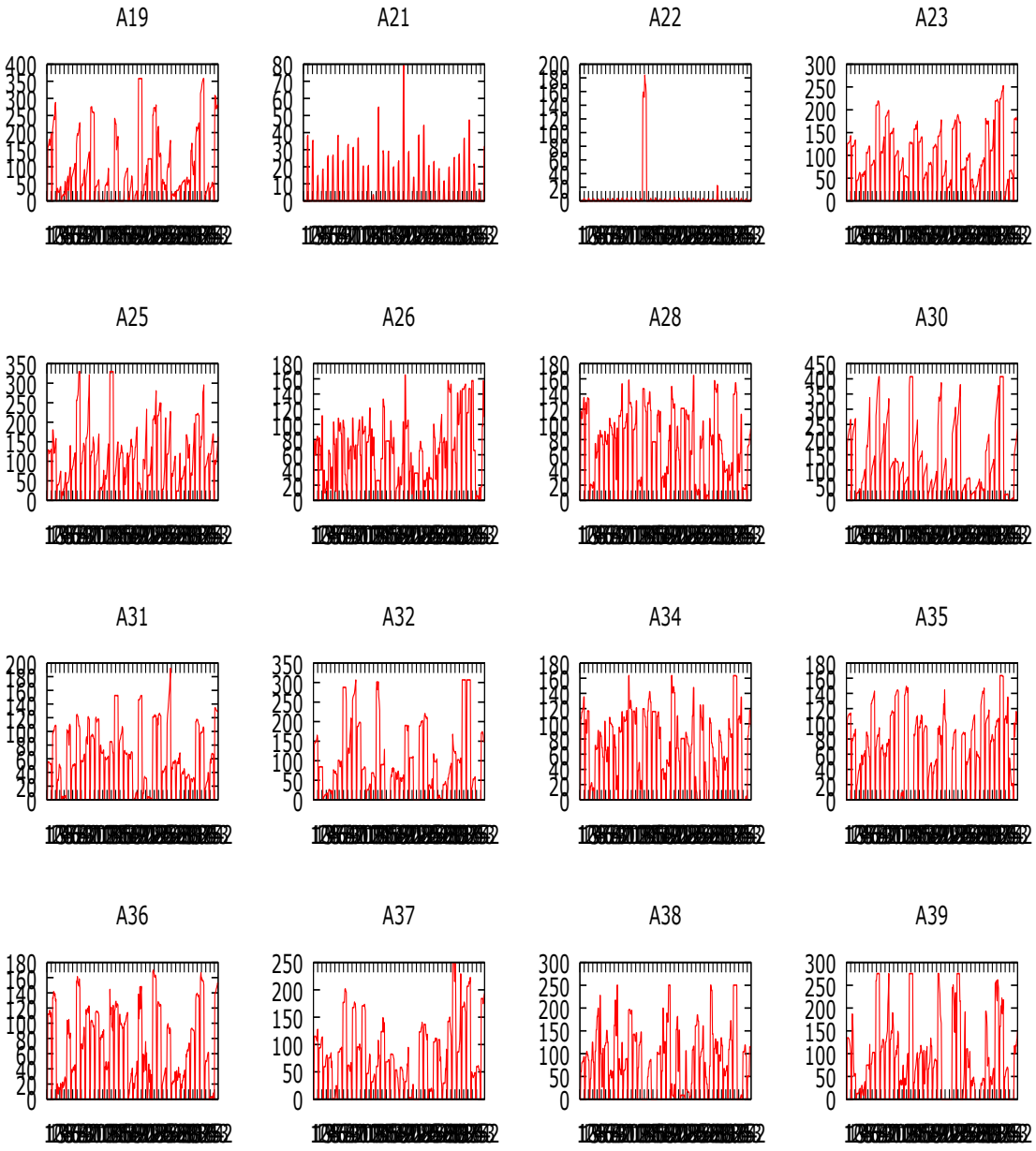

Figura 9. Time Series.

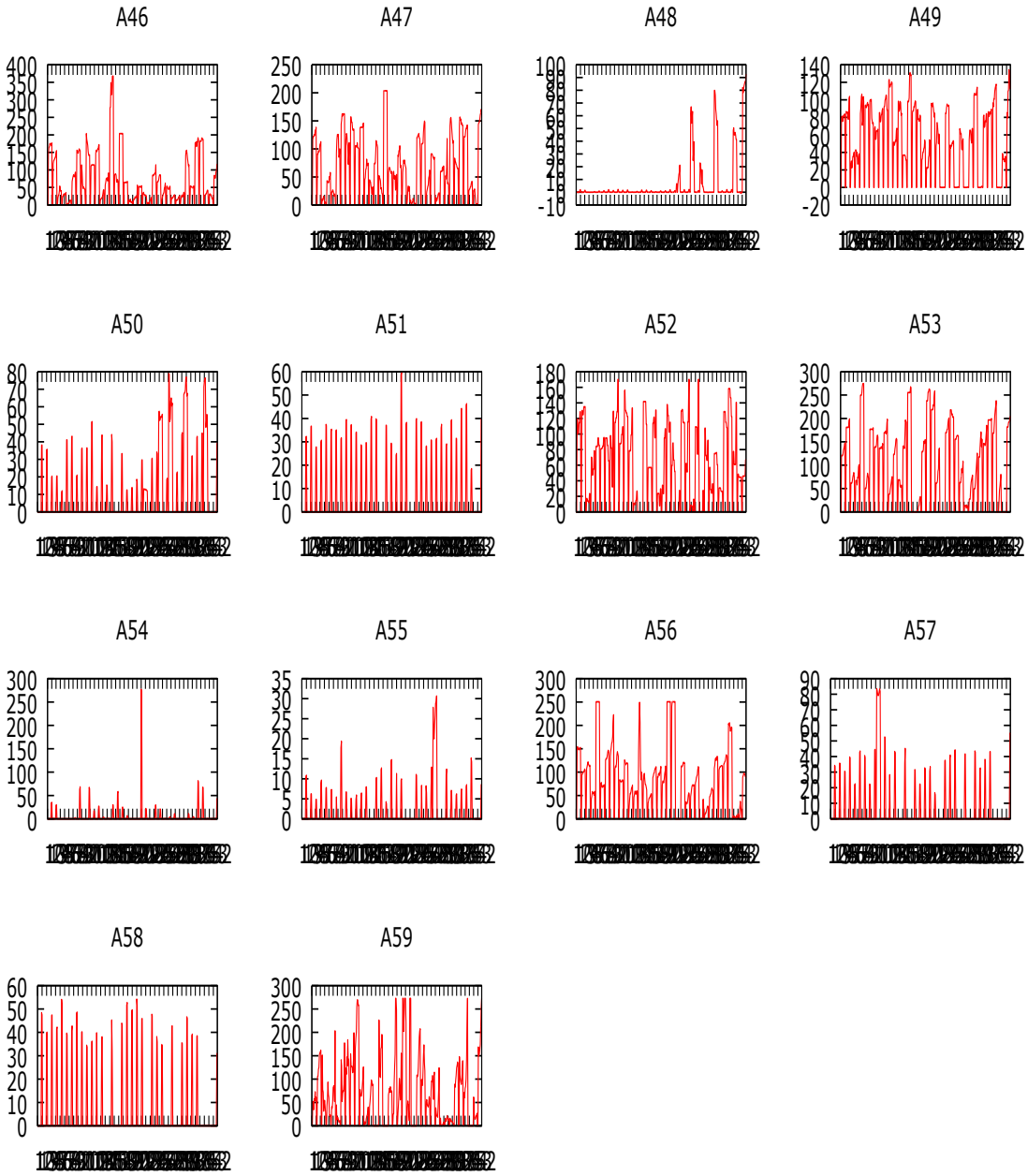

Figura 10.Time Series.

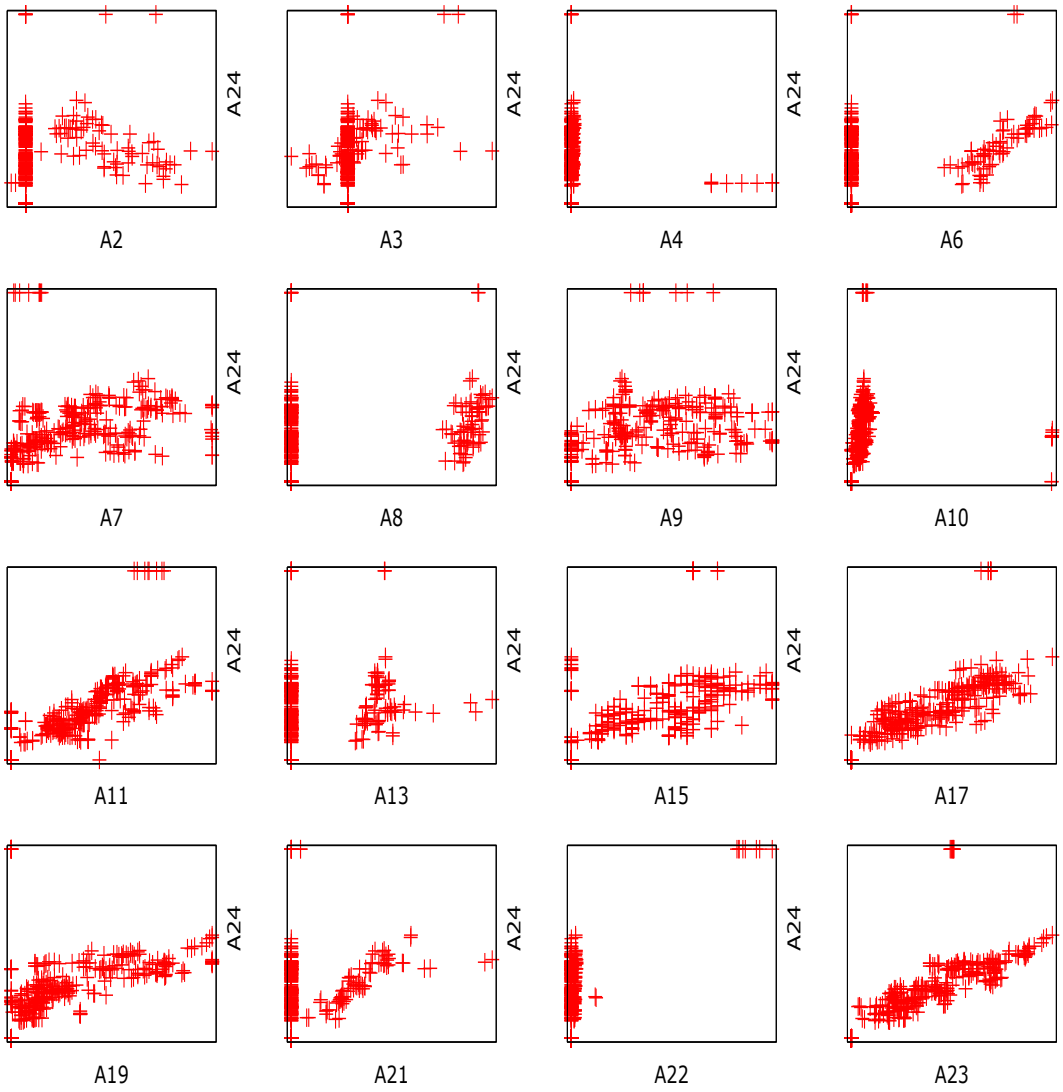

Figure 11. Scatter plot

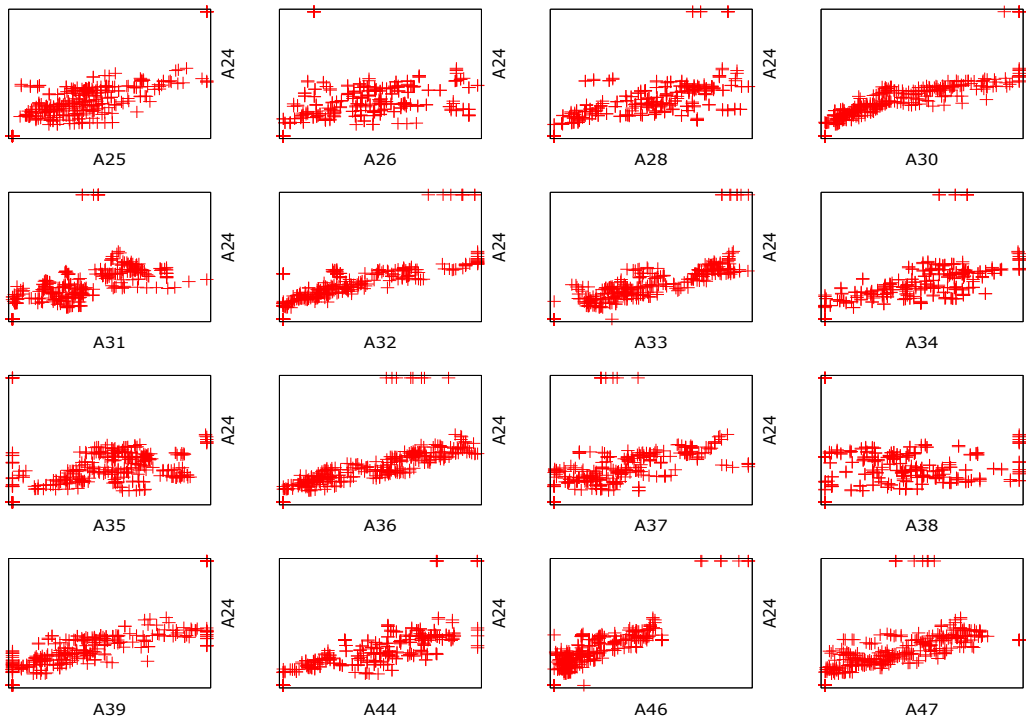

Figure 12. Scatter plot.

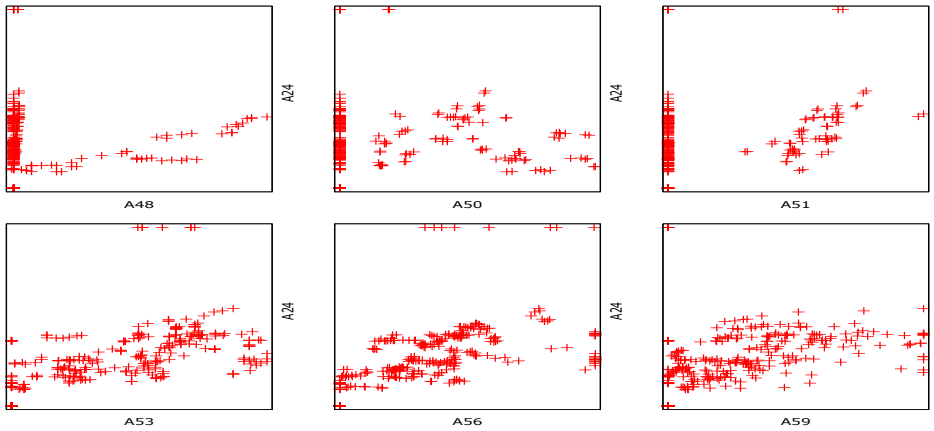

Figura 13. Scatter plot.

DescriptiveStatistics.

Variables	Mean	Median	SSR	Min	Max
A2	0,585	0,00	1,35	-0,510	6,62
A3	0,0840	0,00	0,452	-1,39	3,55
A4	4,23	0,00	26,1	0,00	211,
A6	0,745	0,00	1,52	0,00	5,02
A7	54,3	31,5	56,1	0,00	200,
A8	14,9	0,00	30,2	0,00	85,0
A9	67,5	54,6	62,5	0,00	205,
A10	136,	87,0	323,	0,00	2,02e+003
A11	90,6	89,2	69,8	0,00	254,
A13	9,56	0,00	18,9	0,00	96,1
A15	96,3	96,2	78,2	0,00	254,
A17	66,7	61,5	50,8	0,00	191,
A19	89,8	50,2	101,	0,00	358,
A21	5,59	0,00	12,8	0,00	79,4
A22	4,38	0,00	24,0	0,00	184,
A23	90,9	84,0	68,1	0,00	253,
A25	102,	98,6	84,1	0,00	330,
A26	58,9	61,4	46,9	0,00	165,
A28	68,1	77,1	50,8	0,00	164,
A30	124,	87,7	122,	0,00	407,
A31	60,2	55,5	48,4	0,00	192,
A32	90,8	68,9	93,6	0,00	307,
A33	78,4	70,4	58,6	0,00	188,
A34	66,6	73,3	49,7	0,00	163,
A35	64,6	72,4	49,8	0,00	163,
A36	65,7	58,8	53,8	0,00	170,
A37	75,2	63,4	65,6	0,00	249,
A38	81,6	82,5	72,7	0,00	250,
A39	85,1	67,1	86,2	0,00	276,
A44	70,7	76,1	53,3	0,00	176,
A46	67,5	43,7	72,5	0,00	367,
A47	66,1	59,7	56,8	0,00	204,
A48	6,14	0,00	18,3	-0,764	92,7
A50	10,8	0,00	20,5	0,00	78,9
A51	6,41	0,00	13,9	0,00	59,8
A53	100,	85,5	86,0	0,00	274,
A56	80,5	75,7	71,5	0,00	250,
A59	68,4	47,2	75,6	0,00	273,

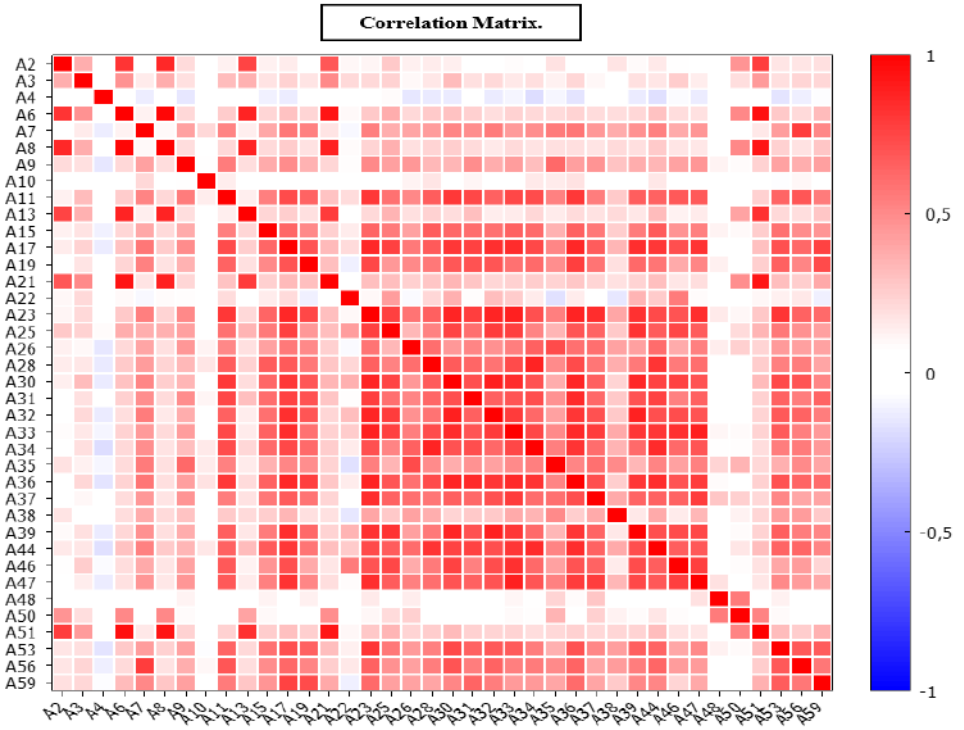

Figure 14. Correlation matrix.

Principal component analysis n = 357 (dropped 2 incomplete observations)			
Analysis of the eigenvalues of the correlation matrix			
Component	Eigenvalue	Cumulative	Proportion
1	16,7248	0,4401	0,4401
2	5,2396	0,1379	0,5780
3	2,3245	0,0612	0,6392
4	1,7873	0,0470	0,6862
5	1,3730	0,0361	0,7223
6	1,2142	0,0320	0,7543
7	1,1132	0,0293	0,7836
8	1,0780	0,0284	0,8120
9	0,9171	0,0241	0,8361
10	0,8591	0,0226	0,8587
11	0,7038	0,0185	0,8772
12	0,5682	0,0150	0,8922
13	0,5526	0,0145	0,9067
14	0,4846	0,0128	0,9195
15	0,4274	0,0112	0,9307
16	0,3455	0,0091	0,9398
17	0,3213	0,0085	0,9483
18	0,3086	0,0081	0,9564
19	0,2648	0,0070	0,9634
20	0,1920	0,0051	0,9684
21	0,1786	0,0047	0,9731
22	0,1499	0,0039	0,9770
23	0,1336	0,0035	0,9806
24	0,1257	0,0033	0,9839
25	0,1011	0,0027	0,9865
26	0,0831	0,0022	0,9887
27	0,0691	0,0018	0,9905
28	0,0664	0,0017	0,9923
29	0,0567	0,0015	0,9938

30	0,0532	0,0014	0,9952
31	0,0391	0,0010	0,9962
32	0,0366	0,0010	0,9972
33	0,0334	0,0009	0,9980
34	0,0288	0,0008	0,9988
35	0,0238	0,0006	0,9994
36	0,0090	0,0002	0,9997
37	0,0083	0,0002	0,9999
38	0,0043	0,0001	1,0000

Eigenvectors

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
A2	0,061	-0,365	-0,028	-0,005	-0,053	-0,029	0,048
A3	0,072	-0,174	-0,157	0,079	0,042	-0,250	0,319
A4	-0,032	-0,028	-0,054	0,043	0,104	0,738	0,146
A6	0,101	-0,387	-0,047	0,030	-0,018	0,056	-0,035
A7	0,152	0,055	0,204	0,187	-0,084	-0,107	0,306
A8	0,091	-0,389	-0,042	0,012	-0,031	0,089	-0,057
A9	0,136	-0,014	0,150	-0,059	-0,039	-0,026	0,466
A10	0,025	0,006	0,090	0,099	-0,486	-0,079	0,123
A11	0,202	0,056	-0,026	0,104	-0,043	0,029	0,189
A13	0,087	-0,355	-0,025	0,063	-0,058	0,088	-0,128
A15	0,173	0,032	-0,013	-0,007	0,039	-0,049	-0,218
A17	0,224	0,050	-0,040	0,061	0,061	0,004	-0,001
A19	0,182	0,047	0,131	0,174	0,273	-0,063	-0,110
A21	0,107	-0,356	0,005	0,085	0,027	-0,028	-0,045
A22	0,049	0,005	-0,511	-0,124	-0,199	-0,104	0,155
A23	0,228	0,066	0,004	-0,033	0,168	0,104	0,021
A25	0,192	-0,014	-0,237	-0,117	0,051	0,207	0,104
A26	0,160	0,014	0,276	-0,126	-0,171	-0,030	-0,106
A28	0,189	0,043	0,016	0,015	-0,293	-0,029	-0,290
A30	0,218	0,055	-0,185	0,058	0,062	-0,066	0,005
A31	0,202	0,052	0,030	0,115	0,063	0,087	-0,088
A32	0,209	0,089	-0,132	0,009	0,122	-0,024	0,049
A33	0,218	0,088	-0,093	-0,145	-0,017	0,105	-0,076
A34	0,199	0,072	0,046	-0,016	-0,225	-0,086	-0,272
A35	0,154	-0,001	0,363	-0,169	-0,161	0,009	0,234
A36	0,225	0,085	-0,015	0,042	0,011	-0,066	-0,098
A37	0,190	0,060	0,094	-0,262	0,067	0,157	-0,026
A38	0,101	-0,026	0,293	-0,003	-0,184	0,360	0,029
A39	0,204	0,075	-0,194	-0,027	0,113	-0,033	0,011
A44	0,212	0,032	-0,020	-0,014	-0,182	-0,044	-0,238
A46	0,182	0,076	-0,270	-0,217	-0,156	0,027	0,170
A47	0,198	0,094	-0,012	-0,198	-0,024	0,099	-0,002
A48	0,027	-0,035	0,177	-0,491	0,310	-0,198	0,058
A50	0,043	-0,246	0,137	-0,442	0,102	-0,142	0,003
A51	0,104	-0,373	-0,025	0,046	-0,005	-0,021	-0,032
A53	0,188	0,018	0,029	0,134	0,259	-0,057	-0,052
A56	0,176	0,032	0,069	0,253	-0,055	-0,102	0,225
A59	0,163	-0,030	0,156	0,309	0,287	-0,067	0,024

	PC8	PC9	PC10	PC11	PC12	PC13	PC14
A2	0,152	-0,035	-0,054	0,055	-0,042	-0,048	0,193
A3	-0,211	-0,204	0,427	-0,322	0,333	-0,003	-0,404
A4	-0,296	0,155	0,370	0,057	-0,168	-0,008	-0,046
A6	-0,049	-0,023	-0,030	-0,038	0,030	0,015	0,074
A7	0,076	0,293	-0,035	-0,218	-0,209	-0,444	0,063

A8	0,005	0,001	-0,087	0,018	-0,007	-0,015	0,150
A9	0,069	-0,424	-0,154	0,467	0,000	-0,074	-0,025
A10	-0,491	0,421	-0,272	0,222	0,303	0,140	-0,125
A11	-0,136	-0,132	0,222	0,049	0,077	0,106	0,401
A13	-0,004	-0,012	-0,080	0,080	-0,060	-0,207	0,028
A15	0,093	-0,034	0,197	0,318	0,145	-0,530	-0,350
A17	-0,001	-0,045	-0,144	0,024	-0,047	0,052	-0,108
A19	-0,234	0,004	-0,001	-0,037	-0,159	0,095	0,071
A21	-0,097	-0,054	-0,013	-0,129	0,064	0,053	-0,011
A22	0,162	0,111	0,177	0,306	-0,167	0,225	-0,030
A23	0,002	-0,010	-0,062	-0,076	0,150	0,067	0,043
A25	0,060	0,108	-0,140	0,078	-0,095	-0,059	-0,198
A26	-0,018	-0,204	0,079	-0,072	-0,274	0,369	-0,208
A28	0,011	-0,059	0,254	0,081	-0,012	-0,042	0,026
A30	0,020	0,089	0,036	-0,149	0,028	0,083	0,073
A31	-0,196	-0,091	0,045	0,225	-0,084	-0,077	0,079
A32	0,064	0,144	-0,140	-0,145	-0,089	0,062	-0,205
A33	0,059	-0,065	-0,053	-0,077	0,162	0,011	0,093
A34	-0,082	-0,055	0,232	-0,054	-0,027	0,002	0,142
A35	0,007	-0,137	0,064	-0,072	-0,254	0,065	-0,044
A36	-0,162	0,010	-0,033	-0,020	0,013	-0,003	0,098
A37	-0,090	-0,020	-0,143	-0,121	0,120	-0,124	-0,196
A38	0,456	0,158	0,050	-0,057	0,377	0,190	-0,107
A39	-0,021	0,115	-0,226	-0,042	-0,116	0,070	-0,051
A44	0,044	0,107	0,072	0,058	-0,122	-0,048	-0,100
A46	-0,028	-0,082	-0,049	-0,121	-0,052	-0,038	0,120
A47	-0,061	-0,156	-0,206	-0,191	0,233	-0,145	0,200
A48	-0,142	0,290	0,222	0,229	0,208	-0,042	0,269
A50	-0,010	0,271	0,081	-0,041	-0,250	0,068	-0,153
A51	0,020	0,019	-0,078	-0,018	0,028	0,058	-0,023
A53	0,262	0,103	0,086	0,198	0,243	0,298	0,011
A56	0,269	0,288	0,207	-0,080	-0,076	-0,081	0,172
A59	-0,076	0,020	-0,089	0,213	-0,071	0,146	-0,158
	PC15	PC16	PC17	PC18	PC19	PC20	PC21
A2	-0,033	-0,250	-0,333	-0,518	-0,107	-0,199	0,099
A3	0,216	0,062	-0,088	-0,155	-0,087	0,012	0,012
A4	-0,037	-0,091	-0,006	-0,009	0,103	0,067	-0,014
A6	-0,046	-0,035	0,015	0,107	0,058	0,057	-0,036
A7	0,065	0,048	-0,051	0,129	0,063	0,235	-0,005
A8	-0,062	-0,090	-0,031	-0,003	0,060	-0,006	-0,039
A9	-0,095	0,158	0,008	0,105	-0,109	0,257	-0,031
A10	-0,116	-0,046	-0,006	-0,104	0,014	-0,037	0,011
A11	-0,167	-0,106	0,208	-0,092	0,008	0,019	-0,015
A13	0,253	0,370	-0,225	-0,038	0,094	-0,002	0,075
A15	-0,314	-0,227	0,092	-0,047	0,164	-0,175	-0,267
A17	0,343	-0,322	0,044	0,069	0,082	0,054	-0,014
A19	-0,174	-0,006	-0,379	0,188	-0,355	-0,109	-0,166
A21	-0,118	0,038	0,229	0,323	0,037	0,165	-0,097
A22	0,072	0,074	-0,174	0,285	0,089	-0,087	0,004
A23	-0,130	0,089	-0,021	-0,085	0,037	0,085	0,200
A25	0,063	-0,071	-0,027	-0,258	-0,206	0,224	0,102
A26	-0,091	0,057	-0,159	-0,179	0,581	0,119	-0,113
A28	-0,116	-0,160	-0,184	0,114	-0,256	0,384	0,234
A30	-0,251	0,093	0,040	-0,023	-0,030	-0,111	-0,105
A31	0,239	0,463	0,197	-0,138	-0,073	-0,215	-0,148
A32	-0,143	0,043	-0,266	0,043	0,001	-0,030	-0,226
A33	-0,021	-0,147	0,115	0,035	-0,000	-0,078	0,077

A34	0,179	-0,007	-0,033	0,032	-0,139	0,210	-0,044
A35	-0,058	-0,115	0,038	-0,037	-0,219	-0,345	-0,050
A36	0,025	0,116	0,041	-0,104	-0,008	-0,165	-0,003
A37	-0,188	0,228	-0,171	0,178	0,060	-0,117	0,510
A38	0,194	0,062	-0,078	0,125	-0,212	-0,077	-0,309
A39	0,008	0,034	0,070	-0,211	-0,048	0,304	-0,343
A44	0,229	0,093	0,155	-0,023	-0,026	-0,159	0,102
A46	0,052	-0,091	0,036	0,215	0,007	-0,296	0,019
A47	0,209	-0,152	0,047	-0,035	0,213	0,095	-0,096
A48	0,168	-0,017	-0,266	0,084	0,154	0,052	-0,148
A50	-0,016	-0,013	0,431	-0,075	-0,231	0,076	0,091
A51	-0,143	0,009	0,112	0,236	0,070	-0,080	-0,092
A53	-0,108	0,138	0,125	-0,143	0,018	0,087	0,212
A56	-0,068	0,052	0,062	-0,054	0,252	-0,066	0,169
A59	0,322	-0,378	0,021	0,185	0,082	-0,118	0,233

	PC22	PC23	PC24	PC25	PC26	PC27	PC28
A2	0,191	0,309	0,012	-0,081	0,109	-0,117	0,175
A3	0,097	-0,012	0,025	0,016	-0,039	0,071	-0,036
A4	0,159	-0,041	0,060	-0,099	0,103	0,012	0,094
A6	0,022	-0,086	0,020	0,073	0,043	0,013	-0,306
A7	0,360	0,067	-0,242	-0,017	0,050	-0,169	-0,065
A8	0,037	-0,043	-0,049	0,031	0,125	0,031	-0,374
A9	0,077	-0,008	-0,012	0,100	0,140	0,153	0,113
A10	-0,006	-0,060	-0,024	-0,093	-0,023	0,022	0,029
A11	-0,243	0,210	-0,201	0,085	-0,006	0,255	0,029
A13	-0,251	-0,284	-0,124	-0,169	-0,252	0,248	0,042
A15	-0,072	-0,030	-0,123	-0,108	-0,059	-0,002	-0,053
A17	-0,004	-0,034	-0,003	-0,149	-0,022	-0,129	0,146
A19	0,155	-0,201	-0,155	-0,028	-0,197	0,241	0,113
A21	-0,089	-0,027	0,189	0,054	0,136	-0,271	0,061
A22	0,071	0,056	0,012	-0,121	-0,137	-0,112	0,004
A23	-0,119	-0,007	-0,087	-0,171	0,072	-0,005	0,109
A25	-0,288	-0,233	-0,103	0,412	-0,028	-0,171	-0,007
A26	0,093	0,020	-0,189	0,136	-0,103	-0,013	-0,007
A28	0,076	0,078	0,283	0,027	-0,275	-0,100	0,055
A30	-0,065	0,108	-0,045	0,113	-0,086	0,039	-0,042
A31	0,062	0,310	0,131	-0,058	-0,148	-0,293	0,008
A32	-0,225	0,075	0,127	-0,036	0,349	-0,036	0,268
A33	0,324	-0,109	0,050	0,217	-0,173	0,106	-0,072
A34	-0,273	0,065	-0,249	-0,223	0,379	-0,095	-0,071
A35	-0,146	-0,304	0,359	-0,197	0,023	-0,153	-0,202
A36	0,090	-0,177	-0,097	0,404	-0,029	-0,362	0,034
A37	-0,043	0,340	0,060	-0,053	0,033	0,016	-0,187
A38	-0,029	0,172	-0,147	0,101	-0,110	0,027	-0,036
A39	0,093	0,191	0,274	-0,187	-0,107	0,222	-0,395
A44	0,245	-0,072	0,192	0,222	0,461	0,480	0,110
A46	0,052	-0,080	-0,307	-0,145	0,031	-0,015	-0,111
A47	0,029	-0,112	0,169	-0,214	-0,165	0,047	0,307
A48	-0,034	-0,017	0,142	0,166	0,090	-0,038	-0,060
A50	-0,006	0,102	-0,238	-0,118	-0,208	0,100	0,197
A51	0,098	0,109	0,080	0,042	-0,020	-0,018	0,376
A53	0,272	-0,339	-0,080	-0,347	0,148	-0,156	-0,060
A56	-0,267	-0,086	0,281	0,056	-0,174	0,123	0,058
A59	-0,137	0,222	-0,043	0,071	-0,067	0,059	-0,145

	PC29	PC30	PC31	PC32	PC33	PC34	PC35
A2	0,146	-0,220	-0,052	0,043	0,036	-0,046	0,008

A3	-0,020	0,066	0,000	-0,008	0,030	0,044	0,013
A4	0,044	-0,001	-0,207	-0,007	-0,015	-0,047	0,002
A6	-0,266	0,074	0,072	-0,093	0,105	0,062	0,101
A7	-0,034	0,019	0,177	-0,018	-0,119	-0,047	-0,191
A8	-0,221	0,187	-0,003	-0,295	0,020	0,258	0,128
A9	-0,006	-0,035	-0,299	-0,045	0,017	0,067	0,089
A10	-0,016	-0,062	-0,013	0,033	-0,009	0,079	-0,004
A11	-0,037	0,063	0,359	-0,102	0,061	-0,236	-0,208
A13	-0,036	-0,082	-0,133	0,085	-0,079	-0,239	-0,274
A15	0,054	-0,039	0,050	-0,031	0,054	-0,033	-0,000
A17	-0,026	-0,052	-0,096	-0,258	-0,085	0,042	0,138
A19	0,186	-0,090	0,163	-0,085	0,119	0,187	0,177
A21	0,223	-0,596	0,107	0,050	0,066	-0,112	-0,012
A22	0,143	-0,022	0,163	-0,297	0,076	0,026	-0,191
A23	-0,148	-0,067	0,100	0,056	0,070	-0,072	-0,051
A25	0,168	0,050	0,323	0,143	-0,144	0,167	0,080
A26	0,001	-0,065	0,084	0,090	-0,034	0,043	0,056
A28	-0,316	0,056	-0,021	0,113	-0,064	-0,187	0,120
A30	-0,044	-0,146	-0,343	-0,161	-0,735	0,033	0,009
A31	-0,205	-0,032	0,177	0,119	-0,007	0,280	0,083
A32	-0,467	0,044	-0,061	0,028	0,209	0,021	-0,200
A33	-0,026	-0,148	-0,179	0,226	0,168	0,373	-0,548
A34	0,304	0,121	-0,247	0,054	0,041	0,288	-0,104
A35	0,040	0,095	0,090	-0,023	-0,147	-0,090	-0,217
A36	0,094	0,184	-0,324	-0,269	0,305	-0,411	0,008
A37	0,235	0,056	0,044	-0,174	0,041	0,005	0,049
A38	0,023	-0,043	0,012	-0,057	0,055	-0,100	0,072
A39	0,249	0,075	-0,091	0,132	0,142	-0,247	0,019
A44	0,012	-0,094	0,172	-0,072	-0,095	-0,117	0,103
A46	-0,128	-0,087	-0,064	0,476	0,043	-0,169	0,403
A47	0,040	0,062	0,135	-0,262	-0,066	0,060	0,092
A48	-0,015	-0,015	0,013	0,135	-0,114	-0,040	0,021
A50	-0,138	-0,043	-0,128	-0,149	0,136	0,036	0,016
A51	0,243	0,604	0,026	0,301	-0,139	0,007	-0,037
A53	-0,003	0,072	0,076	0,056	-0,079	-0,056	0,023
A56	0,114	-0,028	-0,182	0,052	0,259	0,258	0,290
A59	-0,039	0,006	-0,074	0,126	-0,056	-0,088	-0,122

	PC36	PC37	PC38
A2	0,074	-0,044	0,013
A3	-0,069	0,012	-0,005
A4	-0,001	-0,049	0,021
A6	0,728	-0,168	-0,123
A7	-0,004	-0,017	-0,023
A8	-0,593	0,091	0,019
A9	0,010	-0,051	-0,013
A10	0,006	0,005	0,001
A11	0,034	0,184	0,224
A13	-0,023	0,095	0,107
A15	0,011	-0,018	-0,044
A17	0,178	0,678	0,008
A19	0,008	-0,007	-0,005
A21	-0,142	-0,010	0,071
A22	-0,018	-0,122	-0,135
A23	-0,115	0,046	-0,805
A25	0,002	-0,049	0,061
A26	-0,018	-0,012	0,018
A28	-0,085	0,007	0,043

A30	0,058	-0,080	-0,031
A31	0,001	0,011	0,012
A32	-0,011	-0,055	0,258
A33	0,012	0,109	0,029
A34	0,066	-0,115	-0,025
A35	-0,001	0,009	-0,067
A36	-0,033	-0,067	-0,039
A37	0,078	0,099	0,211
A38	-0,014	-0,013	-0,022
A39	-0,024	0,033	-0,033
A44	-0,013	-0,019	-0,083
A46	-0,067	-0,015	0,086
A47	-0,048	-0,462	0,104
A48	0,001	0,110	-0,014
A50	-0,010	-0,083	0,043
A51	-0,006	0,107	-0,081
A53	0,026	-0,049	0,295
A56	0,013	0,023	0,001
A59	-0,101	-0,368	-0,013