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The Attractiveness of European Research Systems

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ABSTRACT: We analyze the determinants of the attractiveness of research systems in Europe in the period 2010-2019. We use data from the European Innovation Scoreboard for 36 countries. The attractiveness of research systems is relevant for the fact the processes of innovation and research and development are associated to more productive economic systems and to higher levels of economic growth. Especially in developed countries the probability to improve the economic growth depends from innovations in the productive system and technology. The ability of a country to attract research and development can have a relevant effect on the prosperity. We found that the attractiveness of a research system is positively associated with "*Business and Entrepreneurships*", "*Innovation Index*", "*Linkages*", "*Performance and structure of the economy*", "*Sales Impacts*" and negatively associated with "*Employment Impacts*", "*Firm investments*", "*Governance and Policy Framework"*, "*Human Resources*", "*Innovators*".
Main concepts:*Knowledge economy, Innovation economy, Schumpterian economics, Solow growth model, National innovation systems.*

I. INTRODUCTION

The passage from The Third to the Fourth Industrial Revolution has changed the relative importance of a set of variables that are essential to promote economic growth and economic development. In particular while in the past the quality of inputs in the productive process was essentially materialistic such as for example the presence of oil, carbon and steel, in the passage to the Fourth industrial Revolution a new input has been introduced in the context of production i.e. knowledge. Knowledge has been declined in many forms either in the form of innovation either in the form of information. Even if knowledge cannot be reduced neither to the definition of innovation since knowledge is also based on past knowledge that is consolidated Knowledge and also because information is just a part of knowledge. With the economics of knowledge can be considered a set of instruments and tools that have either the ability to promote the informatization of the society either to generate new forms of innovations. For similar motivations it is not possible to confound knowledge with technology, for the fact that there is a part of knowledge, especially in the process of discovery through research and development, that should or should not be transfused in technology. So, we can distinguish among different definitions of knowledge either based on innovation either based on information. In the sense of innovation knowledge cannot be reduced to simple innovation since it comprehends also traditional knowledge as showed in following equation:

$$\boldsymbol{KnowledgeInTheSenseOfInnovation_{it}} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{TraditionalKnowledge})_{it} + \boldsymbol{b_2}(\boldsymbol{Innovation})_{it}$$

And if we consider knowledge in the sense of information, we cannot reduce knowledge to information since knowledge comprehend also the hermeneutical tools that are used to evaluated the role of innovation:

$$\boldsymbol{KnowledgeInTheSenseOfInformation_{it}} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{Information}) + \boldsymbol{b_2}(\boldsymbol{ErmeneuticalTools})_{it}$$

$$\boldsymbol{KnoweldgeInTheSenseOfTechnology_{it}} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{ResearchAndDevelopment})_{it} + \boldsymbol{b_2}(\boldsymbol{Technology})_{it}$$

We can consider that knowledge is essentially based on the sum between information and innovation

$$\boldsymbol{Knowledge_{it}} = \boldsymbol{KnowledgeInTheSenseOfInformation_{it}} + \boldsymbol{KnoweldgeInTheSenseOfInnovation_{it}} + \boldsymbol{KnowledgeInTheSenseOfTechnology_{it}}$$

$$\boldsymbol{Knowledge_{it}} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{TraditionalKnowledge})_{it} + \boldsymbol{b_2}(\boldsymbol{Innovation})_{it} + \boldsymbol{b_3}(\boldsymbol{Information})_{it} + \boldsymbol{b_4}(\boldsymbol{ErmeneuticalTools})_{it} + \boldsymbol{b_5}(\boldsymbol{ResearchAndDevelopment})_{it} + \boldsymbol{b_6}(\boldsymbol{Technology})_{it}$$

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The production of knowledge is an activity that requires a deep degree of human capital and human resources. The increasing role of knowledge is in a certain sense compatible with the model of Solow. The in the model of Robert Solow, that has created the base for the theory of economic growth. In effect in the model of Robert Solow the economic growth is based essentially on three factors that are represented in the sequent equation: $\boldsymbol{Y(t) = K(t)^{\alpha}[A(t)L(t)]^{1-\alpha}}$ where $\boldsymbol{K}$ is capital, $\boldsymbol{A}$ is knowledge applied to labour and $\boldsymbol{L}$ is labour. The equation is expressed in a Cobb-Douglass form. Effectively knowledge is able to improve the productivity of labour L but in knowledge is also able to increase the level of human capital creating the conditions for greater productivity. Knowledge, that in the Robert Solow equation is represented by A, can be considered as a tool that can either increase the productivity through technological change and that can also increase the level of labor through the increasing level of human capital.Since knowledge is an essential tool to improve productivity and growth than countries have started a competition and also a collaboration to improve their stock of knowledge essentially trough research and development and innovation. Research and Development and innovation are connected functions but they cannot be confused even if many cases there is a R&D base for innovation, but organizations that are devoted to innovation not necessarily are also active in R&D.

To solve the question of economic growth countries have started a coopetition to improve the level of reasearch and development, to produce more knowledge, to increase the degree and the relevance of innovation. The term coopetition in this case is correct since the challenge has either the characteristics of a competition either the characteristics of a international cooperation. To evaluate the ability of a country to be coopetitive in the international environment is proposed the following measures "*Attractive Research Systems*". The measure "*Attractive Research System*"(European, 2020) is computed by the European Commission for the European Innovation Scoreboard and is composed of the sequent variables: international scientific co-publications, top 10% most cited publications, foreign doctorate students. The presence of attractive research systems is measured by the ability of a national research system to connected in an international context, with international cooperation for international research projects. In this sense there is a sort of coopetition among different countries for the fact that on one sidecountrycompete to acquire the best human capital and researchers and on the other side countries try to cooperate at an international level to produce research. The attractiveness of research system can have relevant spillovers and positive externalities for the innovation that is present in the research system. There is certain relationship among, innovation economics, knowledge economics, and research and development. The role of research and development for economic growth has been considered in many economic theories. In particular the endogenous growth theory has developed a theoretical framework for analyze the role of research and development and human resources in boosting economic growth. Research and development is an essential tool to improve economic growth either in the traditional neoclassical models, that consider the essential role of knowledge for productivity, either in the endogenous growth theory that has been created during in the 80s. The endogenous growth theory has been created to solve the question of economic growth. In effect in the neoclassical definition of economic growth, the entire process of economic development was justified with the presence of exogenous investments that should promote the economic activity. This idea is essentially contested in the endogenous economic theory due to the fact that the endogenous growth theory admits the possibility that inner forces present in the economic system are able to boost the economic activity and among these forces a crucial element is human capital and research and development. It is clear that in the contest of endogenous economic growth the role of human capital is exalted essentially for its ability to createinnovations and research and development. Even if it is not possible to create an identity between the empowerment of human capital and human resources and research and development there is certainly an approximation among the two concepts. In effect human capital can be effectively used for three basic activities that are: the management of existing activities, the process of innovation, research and development.

$$\boldsymbol{HumanCapitalOutputs_{it}} = \boldsymbol{a_1 + b_1(ManagementOfExistingActivities)_{it} + b_2(InnovationProcesses)_{it} + b_3(ResearchAndDevelopment)_{it}}$$

It is clear that a system is devoted to endogenous growth in the sense of innovation in the case in which:

$$\boldsymbol{InnovativeHumanCapital_{it}}: \boldsymbol{InnovationProcesses_{it}} > \boldsymbol{b_1(ManagementOfExistingActivities)_{it} + b_2(ResearchAndDevelopment)_{it}}$$

This is the case of competitive markets and countries that use technological change to improve goods and services. Many innovations are grounded in research and development but in many cases, innovations are marginal improvements in goods and services that are realized to improve the functionalities of goods and services especially in respect to competitive corporations and firms. Generally, innovation is a characteristic of highly competitive markets even if generally more concentrated markets such as monopolies and oligopolies are more efficient in promoting innovations. In effect in highly competitive market, there is a tension to reduce prices and to improve quantities that impoverish the ability of firms to invest efficiently in innovational process. Generally innovational markets and countries are grounded in deeper research and development investments that

generate spillovers that firms can use in the form of marginal improvements to compete creatively. The dynamics of innovations and the economics of innovations have been developed in the framework of the Schumpeterian economics in which entrepreneurs have and essential role in the process of creation new products and markets with technology and pro-innovative institutions.

$$\boldsymbol{ConservativeHumanCapital_{it}}: \boldsymbol{ManagementOfExistingActivities_{it}} > \boldsymbol{b_1}(\boldsymbol{InnovationProcesses})_{it} + \boldsymbol{b_2}(\boldsymbol{ResearchAndDevelopment})_{it}$$

This is the case of traditional industries and economic sectors that shows resistance to change and technological improvements. The traditional sectors characterized by the presence of conservative human capital are generally associated to rent-seeking, exploitation of natural resources and workers. In these cases, the industrial and productive system has an extractive orientation that can be associated positively with the deprivation of resources and the creation of an economy with low levels of efficiency.

$$\boldsymbol{R\&DOriented HumanCapital_{it}}: \boldsymbol{ResearchAndDevelopment_{it}} > \boldsymbol{b_1}(\boldsymbol{InnovationProcesses})_{it} + \boldsymbol{b_2}(\boldsymbol{ManagementOfExistingActivities})_{it}$$

It is the case for more developed economic systems and is also the case that is investigated with the variable "*Attractive Research Systems*". Research and development hasthe ability to improve productivity through knowledge, technology and innovation. Research and development hasalso the ability to shape institutions and to create a more innovative economic environment that is not relegate only in the context of productive firms and research institute but it is also oriented to the society has a whole. Research and Development is the economic value that trigger either the knowledge society either the information society. The outputs of Research and Development have multiple spillovers and positive externalities in the economy, especially for the productive system, and in the society as a whole, for the ability to enrich the social capital.

The attractiveness of research system, that is based on the idea of co-opetition, among countries, can be used as a proxy for a metrical evaluation of Research and Development. But the presence of a connection between Research and Development and Human Capital cannot be considered as a constant. Infact the massive investment in Research and Development oriented to promote artificial intelligence, automation, machine learning and big data, has a dark side for workers i.e. the potential increase of natural unemployment rates. In effect on the one side automation can reduce the employment in manufactories and industries, and on the other side artificial intelligence can reduce the employment in the service sector. The question for western and industrialized economies is essentially the fact that the greater part of the workforce is employed in the service sector and the application of artificial intelligence to professional, creative, and high-skilled jobs could reduce persistently the employment rate with an increase in the natural unemployment rate. Artificial intelligence impedes to create positive and significant connections between human capital and Research and Development. In the future the activity of Research and Development could be realized with the usage of artificial intelligence in a low-tech scenario and by artificial intelligence alone in a high-tech environment.

II. LITERATURE REVIEW

Research and development and economic growth. (Khan, 2015) affords the question of the role of Research and Development in the context of economic growth. The author adopts an historical perspective tracing back the relationship between research and development in the XVIII and XIX centuries even if in the article there is a focus on endogenous growth theory that has been developed during the 80s. The author considers that during the 1990s and 2000s the role of Research and Development has been recognized as an essential factor in the process of economic growth. The author tries to verify if the analysis of Research and Development in the context of industrial countries can offer some tool to analyze also the role of Research and Development in developing countries. In the end the author concludes the article suggesting an activepolitical engagement for government in developing countries to increase their spending in Research and Development as a tool to promote economic growth.

(Aghion & Howitt, 1990)describe the process of creative destruction in the context of schumpterian economics. The authors consider a model based on endogenous growth to investigate the match between the obsolescence of old technologies and the process of innovation based on the accumulation of knowledge through Research and Development activities. The process of substitution of obsolescent technologies with innovations based on knowledge is realized in the context of creative destruction and has relevant effect in the sense of economic growth. In effect the introduction of innovation, and the central theme of schumpterian economics, is the fact to show of an economy can produce more even if it has fixed inputs. The process of innovation can produce an increase in productivity through the introduction of new technologies based on the economics of knowledge that can have a relevant effect on economic growth. The authors consider that the presence of large phenomena of obsolesce in the process of economic growth generate incentives to invest excessively in innovations. Due to the obsolescence firms and markets can be oriented to generate an excessive amount of economic growth. But in an economy oriented to an extreme version of free markets i.e. the laissez-fare, even if there are relevant incentives to invest in innovation, the level of innovations tends to be lower than

the efficient equilibrium due to excessive competition. If firms operate in a pure competitive market oriented to free market and laissez faire than they tend to be more oriented to a competition based on the reduction of prices to conquer customers.

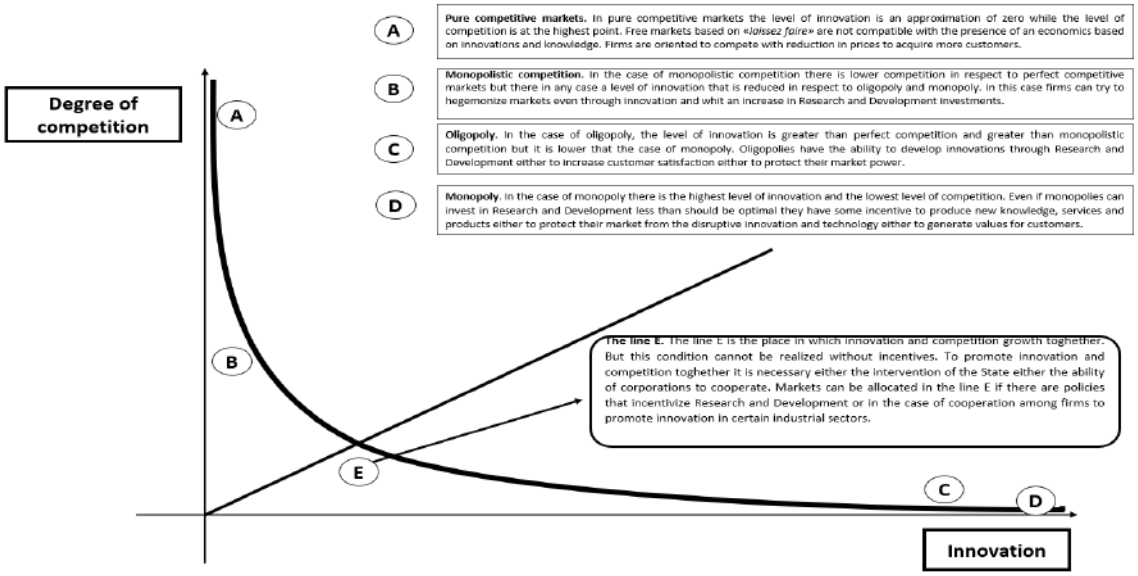

Figure 1. The relationship between the degree of competition and the level of innovation. There is a negative relationship between the level of innovation and the degree of competition in the market. But the possibility to generate a path in which competition and innovation growth toghether, as in the line E, is based on the presence of policies that incentivize Research and Development and on the ability of corporations to cooperate.

Human capital and economic growth. (Engelbrecht, 1997) consider the impact of reasearch and development in the international economics in OECD countries. The role of human capital is considered either in formal and in informal metrics applied to Research and Development. The different measures of human capital created differentiated effects in terms of the estimation of domestic Research and Development and international Research and Development that in both cases remains statistically significant. Human capital as a positive effect in terms of Total Factor Productivity in the sense that it increases the factors of production, andcan have positive effects in terms of international economics and cooperation. Human capital and Research and Development has a relevant impact in terms of the process of economic growth. The author show how human capital and research and development can have an impact in terms of international economics and in terms of economic growth. The author shows how research and development has the ability to improve total factor productivity (TFP). The author considers total factor productivity as a proxy for technological change in the economic processes. This means that in a context of international trade the presence of Research and Development has the ability to boost innovation and technological change in the sense of economic growth. The process of economic growth in OECD countries is positively affected from Research and Development. Research and Development has in impact in improving Total Factor Productivity. The process of Research and Development can be realized at a domestic level or can be determinated in foreign countries, but, in a context of international trade both have positive effects in the sense of economic growth.The author believes that the definition of Research and Development cannot be considered as a proxy for human capital. The author considers that human capital can offer deeper informational meaning to describe a process of economic growth in OECD countries.Human capital has the ability to explain better the mechanism of economic growth based on knowledge, innovation and technological change as it has been introduced by the endogenous growth theory. The author created a distinction between human capital and Research and Development either to promote innovation either to generate international spillovers. The process of technological innovation that is able to boost the economic growth requires an investment either in research and development and in human capital even if there are specific effects that can be expected from human capital and research and development considered individually.

Paul Romer and endogenous growth theory. (Jones, 2019)rebuild the main ideas of Paul Romer Nobel Prize winner in 2018 "[…] *for integrating technological innovations into long-run macroeconomic analysis*".The author recognizes to Romer the merit to have "[…] *rejuvenated the field of economic growth*".In the theory of Romer the process of endogenous growth is based on the development of technological innovation that are realized by profit-maximizing firms to boost economic growth. Technological innovations, research and development and human capital are tools to compete in the free market under the profit maximization constraint. Romer sustains the absence of rivalry among ideas in the process of technological change and innovation. The

author considers the state of the art of the economic growth theory in the 80s when, economists, coherently with the main idea of Solow growth model, believed that growth was essentially based on exogenous forces. Romer, differently from other economists applied to economic growth, has introduced new concepts in the field through the description of the economic incentives and that sustain the efforts that entrepreneurs and researcher have to innovate. Market forces, and especially the constraint of profit maximization is a powerful motivation to innovate. There are many elements that can have an impact on the long run perspective of the economy such as for example, tax policy, basic research funding, education. But in the end the main force that motivate and sustain the process of economic growth is based on the ideas the entrepreneurs and researchers have to develop innovations and new technologies able to boost the process of economic growth. The author believes, that one of the main contributions of Romer was the introduction of the concept of ideas, and in particular the presence of the attribute of non-rivalry among ideas, that is considered as one of the main contributions in the theory of economic growth since the Solow growth theory. Romer has underlined the role of knowledge for economic growth.The introduction of non-rivalry among different ideas in the context of the economics of knowledge is a real innovation in the definition of economic growth. In classical economics goods are considered as rival and based on the idea of scarcity. In particular the fact that an organization use a certain good makes it unfeasible for alternative uses. The scarcity of the traditional mainstream economics created the tensions among prices, and generate the competition among firms to acquire the more productive outputs. Mainstream economics, through the concept of scarcity, increases the orientation of the entire economic system toward a model based on zero sum game and competition among economic actors. In this context the introduction of non-rivalry applied in the context of innovation, technology, research and development, human capital and knowledge change the methodology of value-added creation reducing the competition among firms and creating an economic system based on positive sum game. The passage from the zero-sum game perspectives of the mainstream economics to the positive sum game of the endogenous growth theory has the ability to promote a more sustainable and less divisive process of economic growth. The main contribution of non-rivalry to economic growth is the fact that it creates increasing returns of scale. The development of new ideas and the fact that they are non-rivalry increases the ability of the firm to increase the total productivity of the economic system through the access of increasing return of scale. The difference among doubling rival inputs and improving the realm of non-rival ideas is in the fact that a new factor of productivity increases the level of production of one single worker, or one single plant, while increasing the production of ideas generate e process of economic growth that can be used for the entire economic system improving the productivity of an entire industrial sector. The development of new ideas has the ability to explain how it is possible to improve the level of productivity even if the level of inputs is constant. The only possibility to produce an increasing level of productivity in the short tun especially in the case of constant inputs is to promote innovations, knowledge and technology, through the methodology of producing new ideas. The relevance of ideas in can be also used, historically, to show why countries and economics that have low level of inputs, such as for example a low-levelof natural resources, can obtain relevant results in terms of GDP per-capita by increasing the quality and quantity of ideas and diffusing them among economic actors to improve overall productivity. The development of new ideas can be effectively realized with investments in research institutions, universities, charities and public institutions that are oriented to promote innovations, new ideas and technology.

A critique on endogenous growth theory. (Segerstrom, 1998)affords the question of research and development in the context of endogenous economics growth. The main proposition of the article is to investigate why while there is no positive relationship between the investment in research and development and the creations of patents and innovations. The article in a certain sense is a critique of the endogenous growth theory and states that the investment in research and development has not the ability to generate a positive impact in terms of economic growth and increasing in Gdp per capita. The author shows that the number of people applied in research and development in the United States consistently. But even in the United States and also in other countries either the level of patents either the level of Gdp per capita has remained constant or have showed a certain decline above the average. The author sustains that there is a contradiction between data on one side, since data showsa insignificant relationship between the investment in research and development and the outputs measure in terms of patents, and the theory on the other side, since theory predicts that the increase in Investmnet in research and development can boost either economic growth either the level of technology. The idiosyncrasy between the prediction of the impact of research and development Investmnet and the real impact of R&D on Gdp-growth questions the role of the theory in prescript effective political economies that are able to increase value added and to generate value added either in a quantitative either in a qualitative sense. The main idea of the author is to present a model that is able to shed light on the "*puzzling*" relationship existing among R&D increasing expenditure, the constant number of patents and innovations, and the low rate of increasing in Gdp per capita in contrast with what was predicted endogenous growth theory. The author contrasts either with the idea of the presence of an increasing productivity of workers generated simply with the increase in Research and Development either with the idea of the idea that Research and Development does not have an impact on

value added. The author proposes a model in which the contribution of research and development to the process of economic growth becomes less and less intensive. (Segerstrom, 1998) seems to propose a model in which there are decreasing returns for the investment in research and development. While at the starting point of a process of discovery of new products and services there is a positive return of the investment of Research and Development with the ability to boost Gdp-per capita, but at a certain point the marginal investment in Research and Development does not generate an incremental impact in terms of Gdp-per capita.

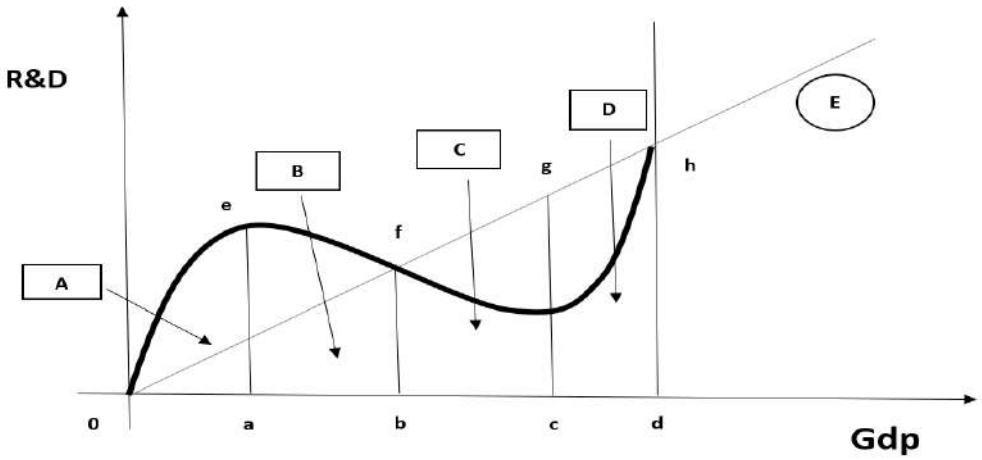

Figure 2. A representation of the relationship between the expenditure in Research and Development and the increase in GDP-growth inspired by (Segerstrom, 1998).

A	**The phase A: R&D opens new markets.** In the area A, that is delimitated by 0, a and e, there is a more than proportional relationship between the increase in Research and Development expenditures and the impact in Gdp growth. This is the case of new discoveries, new patents, or new industrial sectors. In this phase firms invests more in Research and Development to maximize profits. The competition among corporations is attenuated by the production of non-rivalry ideas in the form of knowledge, Research and Development and technology.
B	**Phase B: the declining relationship between R&D and GDP growth.** In the phase B, that is delimitated by the points a, e, f and d the relationship between Research and Development and Gdp-growth becomes declining. The investment in R&D reduces its profitability until the market reach the point f in which the relationship between R&D and Gdp-growth becomes linear i.e. the incremental investment in R&D generates an equivalent incremental improvement in GDP-growth.
C	**Phase C: the declining relationship between R&D and GDP growth under the bisector.** In the phase C, that is delimitated by the points b, c, f and the relationship between Research and Development and Gdp-growth continues to decline and become negative. The incremental investment in R&D generates a lower incremental improvement in GDP-growth. In this phase corporations can survive using mainstream methodology such as reducing price of factors to gain competitivity.
D	**Phase D a reprice in the productivity of Research and Development in respect to GDP-growth.** In the phase D that is delineated by the points c, g, d and h, there is an increase in the impact of Research and Development expenditure in the sense of Gdp-growth, but this improvement is less than proportional and at is relative and absolute maximum reach the point h asymptotically. This is the case of the maturity of the market in which the production of ideas and knowledge generate productivity but insufficiently in respect to improve proportionally the Gdp-growth.

Figure 3. Legend of the areas A,B,C and D as in the figure 2.

R&D, innovation and international trade. (Krugman, 1979) affords the question of two economies that develop technologies to boost the production even if theystart from different position in terms of Gdp-per capita. The economy of the North is productive and innovate with knowledge and technology. The North is able to improve the productivity. The South does not innovate but use the technology developed by the North to generate value added. The North exports products generated with innovation and technology and import traditional products from the South. But to maintain this condition of commercial advantage the North has to invest more in Research and Development, technology and innovation as a defensive strategy to protect the process of economic growth either in absolute either in relative terms. To sustain his vision the author assumes that there is the ability in the economics of the North to produce innovation and technology in order to generate

new products and services to export in the economics of the South. The authorsustains that to better understand the process of international trade it is necessary to consider the methodologies that operate in a micro-dimension. The ability of corporations and firms to generate innovations can help developed economies in preserving rents for elites and income for workers. But if technology is acquired by developing countries than the economic condition of developed countries can change and either rents either incomes can be reduced by the increasing competitions and productive abilities of the developing countries. In this context more protectionist political economies can replace free-trade political economies with the reduction of international trade. But the protectionist defense of mature market could generate greater losses than the ability of developed countries to invest in technology and innovation oriented to boost productivity. For a developed country either competition with a developing country either the protectionism against the developing countries can reduce rents and incomes. Developed countries could better protect their wealth, rents and incomes increasing knowledge, innovation and technology oriented to productivity and growth.

Innovation and economic growth. (Nordhaus, 1969) affords the question of the relationship between the process of technological change and the economic growth. The author suggests that economists refer to a central role of technology in the process of economic growth in that cases in which the dotation of inputs is not able to determine the value of outputs. Since inputs are relatively constant or inadequate to explain the level of outputs than economists conclude that the differential in value is due to technological change. The author considers that, at the time in which he wrote the article, there were no reference of suggestion that the process of economic growth should be imputed to the technological change and not to other economic forcers such as for example "*economies of scale, learning by doing, errors of measurements*". (Nordhaus, 1969) sustains that effectively the difference in value between outputs and inputs can be justified with the usage of other economic determinants that are different from technological change. Economists are not able to explain why there are missing values between inputs and outputs in the sense of economic growth and this inefficiency can be better explained considering on a micro-economic point of view the complex process of transmission of knowledge. To solve the question the author proposes a model to investigate the inventive process in order to describe better and more efficiently the process of distribution of knowledge.(Aghion, et al., 2019)afford the relationship that exist between the reduction of inflation and the process of creative destruction. In particular the absence of inflation is explained considering the process of substitution of products due to innovation. Innovation and technological change operate as a force that has the ability to destroy traditional and non-innovative products and services and substitute them with more technologically advanced services and products. The process of creative-destruction has the ability to reduce the inflation. The authors find that the missing growth is due essentially to creative-destruction. The model applied by the authors is essentially Schumpeterian and is devoted to analyze the role of innovation in the process of measuring the growth of Total Factor Productivity as it results from the application of creative-destruction.

Research and Development and growth.(Jin, 2009) affords the question of the relationship between the process of research and development and the output in terms of economic growth in Asian countries. The author finds that for different typologies of countries there are different typologies of effects in particular: in the case of Hong Kong there is causal relationship between research productivity and economic growth; in the case of Japan there is a causal effect between economic growth and research publication, in Korea and in Taiwan there is a causal relationship between publication and economic growth. In Singapore the relationship between publication and growth is insignificant and small. The author considers the relationship between some variables that represents the process of research and development and the process of economic growth in East Asian countries. For the case of Hong Kong there is a bidirectional effect between research productivity and economic growth. The presence of a bidirectional relationship between research and development and economic output in the case of Hong Kong is due essentially to the fact that Hong Kong is a small city that have international relations and an economic system oriented to the service sector that shows a sort of research-dependence. In the case of Japan, the author finds a positive mono-directional effect between economic growth and research. The author believes that in the case of Japan the mono-directional effect is due to the fact that Japan is a relatively closed economy. In the case of Korea and Taiwan there is causal effect that connect research publications and economic growth an effect that the author explains considering that Korea and Taiwan have invested in foreign journals. In the case of Singapore there is no relevant causal relationship between research and development and the process of economic growth, a phenomenon that the author imputes to the small numbers of universities in Singapore. Buteven if the author has found relevant results that can be justified with cultural and political differences among the main countries of the East Asia there are relevant methodological limitations in the econometric technique that the author has realized: Granger causality. In effect the same idea of the existence of a causality in social and economic phenomena is questionable and, in the end, incorrect. Economists should reject the idea of the existence of causal relationships and should simply verify the presence of associations among phenomena. The presence of causal relationships in social science creates enormous epistemological problems that are essentially connected with the idea of exogeneity. For example, in the case of the relationship

between research and development on one side and economic growth on the other side it is obvious that there is a positive relationship since the activity of research and development not only generate a wealthy economy but are also the output of a wealthy and productive economy. There is relevant question of exogeneity that the author does not afford. But, except for the Granger causality, the author has showed some essential characteristics of the eastern economies that can be generalized in the effort to find a quantitative solution to the functional relationship between research and development expenditure and economic growth.

(Jones, 1995) considers the limitations of the endogenous growth theory for the fact that the "*scale effect"* that was predicted in the theory effectively does not find a confirmation in time series. The author removes one of the main elements of the endogenous growth theory that is the idea that economic growth can be realized maximizing the inner economic forces operating in the economy, and re-introduce some kind of exogeneity to explain economic growth especially in the sense of the increase in the level of population growth. The author expresses a polemic judge on the political implication of the endogenous growth theory explicitly for the implication in terms of fiscal incentives to research and development that government should promote to generate economic growth in the long run. The author questioned one of the main propositions of the endogenous growth theory that states that if the level of resources devoted to Research and Development double that also the Gdp-per capita double. But, the author continues, these prediction does not find the confirmation in data. In the period between the 50s and the 90s the level of investment in research and development is increased consistently while the level of Gdp growth in the same period has been reduced consistently especially in western economies. For example, between 1950 and 1987 the number of scientists and engineers employed in R&D in the USA is passed from 200.000 to 1 million while on the contrary the Gdp-per capita does not have shown the same degree of economic growth. But this trivial observation has not been captured in the models of endogenous economic growth. The author believes that removing the idea of the presence of an economy of scale in Research and Development in respect to economic growth it is possible to reconcile the "*endogenous growth theory*" with a model of growth more similar to the standard "*Solow growth model*". The author believes that in the long run the economic changes that are able to generate growth are essentially exogenous such as in the case of the population growth. The policies that are proposed in the context of the endogenous growth theory can be considered simply as oriented to the short run such as for example in the case of fiscal incentives for research and development and in the case of fiscal subsidies for capital accumulation. The author considers the population growth as an essential force in the context of economic growth since only the increasing number of inventors can generate and improvement in inventions. Finally (Jones, 1995) proposed a model in which there is a sort of semi-endogenous growth in the sense that in the long run the economic growth depends from the investment in research and development that are endogenous, but, in the same model there are exogenous variables such as for example the presence of policies and the population growth. Even if the idea of the author seems to be excessively eclectic and oriented to a sort of hybridism it has also some useful elements of economic reality i.e. the fact the effectively the process of economic growth is always characterized by the presence of endogenous and exogenous forces that toghether shape the economy in the long run. The complexity of technological progress can be better explained with a set of either endogenous either exogenous variables creating a bridge between Solow traditional theory that considers the exogeneity of the process of economic growth and the endogenous economic growth theory.

(Howitt, 2000) affords the presence of a multi-schumpeterian model for economic growth. In this model there is a process of technological innovation that due to transfer generate a certain conformity in growth paths. But countries in which there is no technological transfer can languish in crisis. The author analyzes the presence of transitional dynamics either at a country level either at a world level. In the proposed model the presence of Research and Development investment increases the level of growth even at a greater level in respect to capital accumulation. The role of capital accumulation has a relative impact in respect to the neoclassical theory. The role of Research and Development as an input devoted to explain the economic growth is a precise contribution of the endogenous approach to growth. The author contrasts with the neo-classical interpretation of the economic growth considering that the process of growth is not due to the presence of external investment as suggested in the exogenous models of neo-classical theory, but it is, more oriented to a schumpeterian approach with a relevant role of innovations, entrepreneurs and institutions. There are endogenous variables that can be used to boost the economic growth and that are alternative in respect to external investment. Many countries show different degree of Gdp per-capita. These differences cannot be explained with the neo-classical economic theory. Differences in capital among countries does not have the ability to explain large idiosyncrasies in worker productivity. The schumpeterian approach sustains that changes in productivity are determined by the presence of different productivity levels. The authors explain the presence of different growth rates as an effect of different investment in research and development. Countries that invest more in research and development have higher levels of Gdp growth, while countries that have low investments in research and development will stagnate.

(Baumol, 2002) afford the question of the role of Investmnet in research and development to promote growth. In particular the author considers the differences between the innovation that is realized by corporations and the innovation that is based on the individual innovator. The main difference between the two elements consists in the fact that while corporations have some methodologies to bureaucratize the process of innovation in the case of individual entrepreneurs the innovation is more creative and less normalized in corporate norms, procedures and best practices. But, either the contribution of corporations either the contribution of innovators is essential to promote innovation and economic growth. Both corporations and individual innovators have to invest in research and development and their contributions show the role of R&D as a tool to promote economic growth. The two roles are not in competition but at the contrary they generate an additive effect that create the conditions to a more efficient system of research and development, innovation and technological change that can boost economic growth.

(Aghion, et al., 1997) afford the question of the innovation in the context of firms and competitions. In particular the author considers the relationship between leaders and laggard. Laggards can never be able to win the technological battle with the leaders in the actual market. But if laggards have the ability to generate a level of innovation that is aa proxy in the actual leader of innovation than in the future the laggard can be able to beat the leader in the sense of future innovation. In the model that is analyzed the presence of competition among firms, that in the model is based on the relationship between the laggard and the leader, can promote an increase in the level of innovation and boost the economic growth.

(Arkolakis, et al., 2018) afford the question of the distinction between countries that are specialized in the context of innovation and countries that are specialized in production. The difference between these two specializations is based on the idea of the competitive advantage. Specialization is essentially based on endogenous motivations that area connected to relative increasing returns in each sector. The reduction in costs of production and the integrations od Asian economies, such as for example China, can reduce the economic convenience of countries that are specialized in production processes. The authors find that workers can obtain gains even if they operate in countries that are oriented to innovation.

Human capital and endogenous growth theory.(Romer, 1990) affords the question of technological change that is realized through investment choices of corporation under the profit maximization constraint. The author defines technological change as a particular good that is neither perfectly private neither perfectively public. Technological change can be assimilated to a public good even if there is the possibility to introduce some kind of limitation in its access and usage such as in the case of patents and intellectual property rights. Technological change is considered as a hybrid good that has in common with public goods the non-rivalry and with private goods the fact to be partially excludable. But the fact that technological change is characterized by non-rivalry modifies the structure of the market, reducing the efficiency to realize price competition and orienting the market toward monopolistic competition. The author concludes that:

- *Human capital determines the rate of growth:* the role of human capital in the process of economic growth is not a unique characteristic of the endogenous growth theory. Similar results are also predicted in Solow's growth model, especially in the long run. In effect also in the Solow model the role of human capital is crucial either to generate knowledge, to improve technology and the efficiency of labour. But in the endogenous growth theory the role of human capital is a crucial element to boost productivity not only in the long run but also in the short run. Firms, that in the model of Romer are profit maximizers can effectively improve their economic results through the enrichment of human capital especially with the investment in research and development. Finally, human capital is able to justify the increasing value of outputs even in the conditions in which inputs are constant.
- *Too little human capital is devoted to research in equilibrium:* in the model of Romer the investment in research and development is an essential part of the process of economic growth. Since knowledge, innovation, research and development are able to boost the technological change and to increase the level of ideas that are diffused among the corporations, then the increase in the level of investment in research and development has the ability to reduce the difference between the potential and real output. In the model of endogenous growth theory, the only possibility to improve the level of output in the short term, considering that the level of inputs is essentially constant, is based on the investment in research and development that promote technological change. Corporations operate in the context of profit maximization even if the production of technological change and in particular the innovational process of through ideas is able to generate non-rivalry goods. Corporations are essentially oriented to profit maximization in performing research and development even the entire process of technological change generate ideas that are characterized by non-rivalry.
- *Integration into world markets can increase growth rates:*the level of international integration of the research and development system can improve the ability to produce economic growth. In particular, in the model of Romer, the presence of innovation, research and development have the ability to generate economic growth even with mechanism of collaboration and cooperation at an international level.

Research and development isassociated positively with the development of international cooperation and collaboration. The possibility to promote integration offers to corporations the ability to generate value through the investment. The integration among countries generates also cooperation and the ability of countries to be able to develop economies of scales and scope to boost technological innovation. The ability to promote the process of distribution of knowledge among different countries and the ability to generate international cooperation can increase the process of economic growth based on technology and innovation.

- *The presence of large population is not sufficient to generate growth:* in traditional models of economic growth the increase in population was considered as an essential variable. But the endogenous growth theory questioned this variable. It is not the large population per se that can boost growth, but it is the diffusion of knowledge and research and development among the population that can promote the economic growth.

Productivity and social infrastructure.(Hall & Jones, 1999)afford the question of the difference in output per worker in many different countries. The authors find that two main variables are able o explain the enormous divergence in productivity among countries and that these two variables are: physical and educational capital. But either the physical capital and human capital is determined by the massive use of what authors call "*social infrastructure*" i.e. the presence of institutions and government policies that are able to boost either growth either development. Authors find that the presence of social infrastructure is endogenous. Social infrastructure is determined by historically location and cultural factors such as language. But, even if the analysis of the author can be accepted during the 2000s it is no more valuable in the aftermath of the internet revolution and in the context of the Fourth Industrial Revolution. In particular, due to internet and the quaternarization of the economy, developing countries have lowered the cost to import new technology, culture and institutions, and have more and deeper probability to reduce the gap with more developed countries.

Exploitation and Exploration in Research and Development. (Akcigit & Kerr, 2018)afford the relationship between exploration and exploitation of innovation and their impact for economic growth. In particular the exploration is based on the creation of new innovations, while the exploitation is the usage of existing innovations to promote economic growth. Firms use exploitation and exploration to obtain different goals. In particular exploration can be realized to produce new products and services. Exploitation can be uses to improve the performance of existing product lines. The authors find that the heterogeneity in firm behavior has a relevant in improving the role of research and development in respect to economic growth. In particular small firms seem to have strong incentives to massively invest in research and development especially in exploitation. In effect while big corporation have many products and services to develop and are more oriented to afford the exploitation of research and development. The authors in this way show that there is a particular role that newcos, small and medium enterprises, and new incumbent can effectively have to boost innovation and technology even in new fields and new scenarios. In particular the authors find that in some economies such as for example in USA the impact of exploration is greater than the role of exploitation in the sense of economic growth and economic development.

The market of ideas and patents. (Akcigit, et al., 2016) afford the question of the role of ideas in the production of economic growth. The development of ideas is an essential tool to promote the productivity of each firm. But the role of an idea in the context of firm productivity is strictly connected with the business activity. Firms have to consider the cost of production and development of an idea with the cost of buying patents on the market. But even if a firm produces ideas and products it should also consider the possibility to sell ideas as patent in the market. The authors analyze the level of efficiency in the patent market and how it affects growth in respect to the ability of the firm to produce new ideas. Some ideas and patents are useful for the business of the firm. Other ideas are not usefulfor the development of the business of the firm and in this case the firm sell the idea on the market. Both the typology of ideas can generate profit either in the case in which the ideas are used in the business process of the firm either in the case in which the ideas are sold in the market of patents. Research and development generate value either in the case of ideas that are developed to boost the productivity of the firm, either to increase profit with the market of patents. Firms that have Research and Development departments tend to sell an amount of ideas between 15 and 20% in the form of patents. But generally, firms sell only that patents that are distant from the firm business. Since reasearch and development department tends to generate innovations that are in the strict interest of the corporation, then the percentage of patents that can be sold in the market are very low. But on the other point of view there is another limitation in the possibility of firms to develop patents for the market i.e. the risk to offer new solutions to increase the competitivity of concurrents. The ability of firms and corporations to produce patents is strictly connected with the usability of new ideas and research in the sake of corporations. In particular, if a firm develop ideas and innovations to promote its own business than there is a low probability that these ideas could be sold in the market as patents. But, if a firm, during the realization of a process of research and development has the ability

to generate innovations that are not strictly connected with the main business of the firm then the firm has greater probability to sell these ideas in the market in the form of patents. In this sense there is a positive externality that is realized in the market through the investment of research and development, since, even corporations that are strictly oriented to profit maximization, can produce value in markets different from their own with an impact in terms of productivity for corporations.

Technological change and various economic theories. (Sredojević, et al., 2016) afford the question of the role of technological change in the context of economic growth theory. In particular authors present a confrontation among three different typologies of economic theories that are the neoclassical theory of Solow, the endogenous approach of Romer and the evolutionary approach of Freeman. Even if these models are different in their explanation of the essential determinants of the economic growth, all these models share the common recognition of the role of technological change as a driver of the economic growth. Authors recognize the role of the neo-classical theory in describing the technological change as an essential driver of the economic growth. Also, the supporters of endogenous growth theory have had a relevant impact in promoting technological change as a tool for economic growth, underlining the presence of positive externalities in knowledge, science and research and development in the process of diffusion of innovation. But, evolutionary and institutional economists, as in the case of endogenous growth theory and in the case of classical growth theory have had a relevant role in promoting the development of innovations suggesting that the social and institutional environment can have a relevant role in promoting economic growth. The authors believe that all these theories have had a role in the building process of that particular kind of economics that is the economics of knowledge that is the substantial base of the so called fourth-industrial revolution.The particular contribution of endogenous growth theory is the role of technological change and innovation as a tool to solve the reduction of productivity that is associated to the application of classical economic theory. In the endogenous growth theory, the main elements of the economic growth are knowledge, research and development and the formation of the human capital through a process of investment in education, universities and culture. Knowledge is considered as a productive factor such as labour and capital that firms can use to increase the outputs in a profit maximizing model. The main effect of knowledge, innovation and research and development as a key factor in the production process consists in contrast to non-diminishing returns. By introducing the role of innovation and technological change considered as an output that firms can maximize investing in research and development and in the context of knowledge, the endogenous growth theory has removed one of the essential limitations to the economic growth that in the neoclassical theory of growth was based on the diminishing returns of factor productivity. Endogenous growth theory has internalized the level of knowledge and innovation increasing the ability of the economic system to produce in a more durable path of sustained economic growth.

Input-Output analysis and endogenous growth theory.(Los, 2001)realizes an input-output model based on endogenous growth theory with the incorporation of innovation, knowledge spillovers, constant return of scale and full employment. The author believes that the usage of Input-Output analysis can be useful to solve the gap between "*economic theory and factual observation".*The main point of the author is the fact that the presence of differences among industries and technological linkages has a relevant impact on the ability of Research and Development to promote long run growth. Input-Output matrix can have a relevant impact in the process of analysis of the endogenous growth theory. The author finds that in the decision of investment in Research and Development, the firm has to choose between increasing the future productive capacity through physical capital goods and the reduction of labor requirements from the investment in labor-saving innovations. The usage of Input-Output matrix is effectively compatible with the idea of the endogenous growth theory that knowledge, innovation and research and development can be considered as an input. The input-output matrix is coherent with the idea of endogenous growth theory to normalize the presence of research and development in the factor productivity as a normal input that generate technology and innovation.

Research and development, knowledge and economic growth.(Braunerhjelm, et al., 2010) in this article the author refers to the usage of endogenous growth theory in the recognition of the role of the theory for the effects of knowledge and research and development as a tool to promote growth through positive externalities and spillover effects. In the endogenous growth theory knowledge is not a perfectly private good, for the fact that there are positive externalities, neither a pure common good, for the presence of patents and intellectual property rights. Knowledge, research and development,innovation and technology have either some elements of pure public goods, such as for example for the presence of positive externalities and absence of rivalry, either some element of private goods, such as for example the presence of patents and intellectual propriety rights. The author shows that economic growth is essentially based on knowledge accumulation either generated by incumbents either based by the innovational process that is realized in the productive process of firms and entrepreneurs. But the presence of knowledge per se is not a sufficient guarantee of the presence of a productive knowledge, that is a set of knowledge that can be used economically in firms, corporations. Not all the existing knowledge can be transfused into a productive process contributing to the generation of products and services based on innovation and research and development. Authors recognize the relevance of

entrepreneurs in the process of producing products and services based on knowledge. Finally, authors perform a Granger test to verify the causality of the direction of knowledge from entrepreneurs to economic growth. Authors in recognizing the role of knowledge such as in the context of the endogenous growth theory effectively underline also the role of entrepreneurs as in the schumpeterian theory. For these motivations, their analysis cannot be considered as a pure endogenous in the sense of economic growth, but should be considered as a mix between endogenous growth theory and schumpeterian economics, especially for the recognition of the role of entrepreneurs in boosting the process of growth and development. This connection, between endogenous growth theory and the schumpeterian economics, can be considered as "*natural*" in a certain sense, at least for the fact that the economics of innovation has developed potentially many of the themes and propositions that have been subsequently realized in the context of the economics of knowledge. But there is also a critique that we have to move to the article that is connected to the usage of granger causality. The usage of the Granger causality cannot effectively determine the unique identification of a relationship based on cause-effect relation. Economists should reject the idea to find causal relationship among socio-economics and financial variables and should accept the fact that stating the presence of associations among phenomena can be sufficient to the investigation of the economic epistemology.

Fiscal policies, R&D and innovations. (Acemoglu & Cao, 2015)present a model in which there are two different typologies of economic actors in respect to innovation: on the one side there are incumbents that use technology to develop their own products, while there are new entrants that are oriented to a more revolutionary innovative behavior. The authors consider the contributions in terms of economic growth that either incumbents either new entrants generate in the market. In the model that is analyzed the presence of subsidies in respect to new entrants reduce the level of economic growth in the market since incumbents are constrained to use part of their resources to compete with new entrants instead to produce innovations. The author find that standard economic growth theory does not consent to analyze the twofold effect of the innovation that is generated by new entrants-especially in connection with the process of creative destruction-and the presence of a connection in the mechanism of generating innovation between new entrant and incumbents. In effect the relationship between incumbents and new entrants is essential to create the conditions that can produce a greater level of innovation in the market economy as a whole. But generally, there is a negative trade-off between the level of innovation in an economy and the level of competition: in effect, highly competitive markets are not able to sustain the development of structural innovations that can have the ability to generate productivity and economic growth. But, on the contrary, less competitive markets, even if they should not be neither monopolistic neither oligopolistic could be more able to sustain larger investment in research and development able to produce innovations. In the model that is presented in the article there are two different typologies of technology: one type of technology is used from incumbent firms to promote improvements in their products, the other type of technology is used from new entrants to promote innovation and to "revolutionize" the market with an impact in the sense of creative destruction. The authors suppose, coherently with the "Arrow replacement effect" that incumbents improve marginal innovations, while new entrants are more "radical" in their innovative impact in the market. The level of risk-taking in the process of innovation is substantially different if it is measured from incumbents or from new entrants. In particular, incumbents do not experiment new products and services, and in this sense they prefer a model based on low risk-taking, while on the other side, new entrants are less risk-averse in the sense of innovation and use technology to try to trigger the process of creative-destruction that could open the possibility to greater profits in the market. Due to these assumptions the model proposed is able to distinguish between the specific contribution of the incumbents on the one side and new entrants on the other side. But, the authors retain that the contribution in terms of innovation of incumbents is greater than the contribution of new entrants. The continuity in which a firm generate knowledge, innovation, technology, through the investment in research and development, has a relevant impact measured in terms of contribution to economic growth. In this sense, the authors seem to prefer the process of continuous innovation among certain paths that are chosen by incumbents, to the more dynamic and "*radical*" process of "*creative-destruction*" that more aggressive firms in the sense of innovation can generate in the market. The authors suggest that if the presence of barriers or taxes for new entrants is associated to greater outputs in the sense of innovations, since incumbents instead to use financial resources to fight in the market, can use their resources to invest in research and development and innovation.

(Acemoglu, et al., 2018) afford the question of the political economies that can be used to incentivize research and development that can promote economic growth. The authors find that industrial policies that are devoted to punish low level innovators and to promote high level innovators have relevant results in terms of the increase of economic growth. In the idea of the authors it is better if policy makers incentivize low innovators incumbents to exit from the market and at the same time create the conditions to generate relevant incentives for more efficient enterprises. The authors statues that even if there is an underinvestment in research and development, the solution of the problem is not to incentivize R&D activities since in this case the government subsidize either low performing firms either high performing firms. The optimal policy for the government is to

subsidize only high performing firms in the sense of research and development. In synthesis while high performing firms should be incentivized, low performing firms should receive some penalties in the form of taxation.

Research and development and risk taking. (Galasso & Simcoe, 2011) afford the question of the relationship between CEOs' overconfidence and the ability of firms to innovate. Authors find that there is a positive relationship between CEOs' overconfidence and the ability to innovate. CEOs' overconfidence is considered as the ability of CEOs to underestimate the risks and costs of innovations. More specifically CEOs' overconfidence is considered as an underestimation of the probability of failures. These CEOs that have overconfidence have good results in pushing their firms towards new frontiers of technological change. There is a positive relationship between CEOs' overconfidence and the ability of the firms to produce innovation and to promote improvement in the technology. Overconfidence can increase innovation. In particular the effect of overconfidence in promoting innovation growths with the degree of market competition. The greater the market competition the greater the ability of overconfidence to promote innovation. Specifically, CEOs' overconfidence is associate with more cite-weighted patents. Overconfident CEOs are more able to promote innovation and technological change.

III. THE MODEL

We have estimated the sequent model:

$$\begin{aligned}\boldsymbol{AttractiveResearchSystems}_i &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{BuyerSophistication})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{EnterpriseBirthsWithMoreThan10Employees})_{it} \\ &+ \boldsymbol{b_3}(\boldsymbol{EmploymentFastGrowingEnterprisesOfInnovativeSectors})_{it} \\ &+ \boldsymbol{b_4}(\boldsymbol{NonR\&D}InnovationExpenditure)_{it} + \boldsymbol{b_5}(\boldsymbol{R\&D}ExpenditureBusinessSector)_{it} \\ &+ \boldsymbol{b_6}(\boldsymbol{BasicSchoolEntrepreneurialEducationAndTraining})_{it} \\ &+ \boldsymbol{b_7}(\boldsymbol{EaseOfStartingABusiness})_{it} \\ &+ \boldsymbol{b_8}(\boldsymbol{GovernmentProcurementOfAdvancedTechnologyProducts})_{it} \\ &+ \boldsymbol{b_9}(\boldsymbol{RuleOfLaw})_{it} + \boldsymbol{b_{10}}(\boldsymbol{NewDoctorateGraduates})_{it} \\ &+ \boldsymbol{b_{11}}(\boldsymbol{TertiaryEducation})_{it} + \boldsymbol{b_{12}}(\boldsymbol{InnovationIndex})_{it} \\ &+ \boldsymbol{b_{13}}(\boldsymbol{MarketingOrOrganizationalInnovators})_{it} \\ &+ \boldsymbol{b_{14}}(\boldsymbol{SMEInnovatingInHouse})_{it} + \boldsymbol{b_{15}}(\boldsymbol{InnovativeSMEsCollaborating})_{it} \\ &+ \boldsymbol{b_{16}}(\boldsymbol{PublicPrivateCoPublications})_{it} \\ &+ \boldsymbol{b_{17}}(\boldsymbol{EmploymentShareManufacturing})_{it} \\ &+ \boldsymbol{b_{18}}(\boldsymbol{ShareHighAndMediumHighTechManufacturing})_{it} \\ &+ \boldsymbol{b_{19}}(\boldsymbol{ShareKnowledgeIntensiveServices}\%)_{it} \\ &+ \boldsymbol{b_{20}}(\boldsymbol{TurnoverShareLargeEnteprises})_{it} \\ &+ \boldsymbol{b_{21}}(\boldsymbol{MediumAndHighTechProductExports})_{it}\end{aligned}$$

Since every variable can be considered as a tool for the main the determinants of macro-variables, we can rebuild our model summing up variables. We have that

$$\boldsymbol{BusinessAndEntrepreneurship}_{it} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{BuyerSophistication})_{it} + \boldsymbol{b_2}(\boldsymbol{EnterpriseBirths})_{it}$$

$$\begin{aligned}\boldsymbol{EmploymentImpacts}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{EmploymentFastGrowingEnterprisesOfInnovativeSectors})_{it}\end{aligned}$$

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

$$\begin{aligned}\boldsymbol{GovernanceAndPolicyFramework}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{BasiSchoolEntrepreneurialEducationAndTraining})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{EaseOfStartingABusiness})_{it} \\ &+ \boldsymbol{b_3}(\boldsymbol{GovernmentProcurementOfAdvancedTechnologyProducts})_{it} \\ &+ \boldsymbol{b_4}(\boldsymbol{RuleOfLaw})_{it}\end{aligned}$$

$$\boldsymbol{HumanResources}_{it} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{NewDoctorateGraduates})_{it} + \boldsymbol{b_2}(\boldsymbol{TertiaryEducation})_{it}$$

$$\begin{aligned}\boldsymbol{Innovators}_{it} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{MarketingOrOrganisationalInnovators})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{SMEsInnovatingInHouse})_{it}\end{aligned}$$

$$\boldsymbol{Linkages}_{it} = \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{InnovativeSMEsCollaborating})_{it} + \boldsymbol{b_2}(\boldsymbol{PublicPrivateCoPublications})_{it}$$

$$PerformanceAndStructureOfTheEconomy_{it} = a_1 + b_1(EmploymentShareManufacturing)_{it} + b_2(ShareHighAndMediumHIghTechManufacturing)_{it} + b_3(ShareKnowledgeIntensiveServices)_{it} + b_4(TurnoverShareLargeEnterprises)_{it}$$

$$SalesImpacts_{it} = a_1 + b_1(MediumAndHighTechProductExports)_{it}$$

A synthesis of the results is in the following table:

Synthesis of the regressions								
	WLS		*Pooled OLS*		*Fixed Effects*		*Random Effects*	
Coefficient	-0,0885978		1,34474		0,46644		0,538141	
A4	-0,195197	***	-0,2054	***	-0,1578	**	-0,163249	***
A6	8,31898	***	10,6708	**	5,34877	*	5,83347	**
A8	-0,463184	***	-0,69409	***	-0,3297	**	-0,359116	***
A9	-0,238081	***	-0,35183	***	-0,2304	***	-0,246423	***
A12	0,623037	***	0,81807	***	0,68767	***	0,708421	***
A15	-0,17063	***	-0,16251	***	-0,1084	***	-0,11657	***
A22	-2,57858	***	-2,84657	***	-1,9972	***	-2,10838	***
A24	2,43535	***	2,52484	***	1,78994	***	1,87683	***
A27	0,0443191	***	0,10058	***	0,05258	**	0,0580535	**
A34	-0,228265	***	-0,31478	***	-0,1868	***	-0,196701	***
A35	0,0553856	**	0,15682	***	0,10532	**	0,111862	**
A37	-0,048637	**	-0,1307	***	-0,0747	*	-0,081897	**
A38	-0,154334	***	-0,13965	***	-0,115	***	-0,119938	***
A45	0,284131	***	0,3009	***	0,28262	***	0,283782	***
A46	-0,581802	***	-0,51496	***	-0,295	***	-0,316213	***
A48	0,667491	***	0,68555	***	0,49869	***	0,529229	***
A50	-0,775197	***	-0,89673	***	-0,6465	***	-0,687387	***
A51	0,626551	***	0,86001	***	0,4083	**	0,456095	**
A52	-0,300901	***	-0,38489	***	-0,224	***	-0,244846	***
A53	-0,161399	***	-0,18769	***	-0,0569	*	-0,071535	**
A57	0,414952	***	0,42007	***	0,37373	***	0,379112	***

IV. CONCLUSION

We analyze the determinants of the attractiveness of research systems in Europe in the period 2010-2019. We use data from the European Innovation Scoreboard for 36 countries. In analyzing the role of research and development for economic growth we have considered also the endogenous growth theory. The endogenous growth theory has been developed by many economists during the 90s and 2000s and in particular can be referred to the work of Paul Romer that in 2018 won the Nobel Memorial Prize in Economic Sciences. The endogenous growth theory has been chosen to explain the results of the model for the fact that this theory attributes a significant role to knowledge, human capital, innovation, ideas and technology in the process of economic growth. The endogenous growth theory is also relevant for the fact that consent to explain the differences in productivity among countries that cannot be described controlling for capital factor exclusively. The endogenous growth theory considers Research and Development as a in input in the real economy and permits to explain the role of technology in generating high profitable outputs in presence of substantial fixed inputs. In the light of this theory, we argue that the ability of a country to attract research and development investments can have a relevant effect in the process of economic growth. Our econometric results show thatthe attractiveness of a research system is positively associated with "*Business and Entrepreneurships*", "*Innovation Index*", "*Linkages*", "*Performance and structure of the economy*", "*Sales Impacts*" and negatively associated with "*Employment Impacts*", "*Firm investments*", "*Governance and Policy Framework"*, "*Human Resources*", "*Innovators*".

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Appendix

Beta	***Variables***	***WLS***	***POOLED OLS***	***FIXED EFFECS***	***RANDOM EFFECTS***
1	***Business and entrepreneurship***	8,14835	10,5083	5,24036	5,7169
2	***Employment impacts***	-0,2381	-0,3518	-0,2304	-0,2464
3	***Firm investments***	-0,7361	-0,6546	-0,41	-0,4362
4	***Governance and policy framework***	-2,5695	-3,0605	-1,986	-2,1015
5	***Human resources***	-0,21	-0,3184	-0,1316	-0,1534

6	Innovation index	2,43535	2,52484	1,78994	1,87683
7	Innovators	-0,5292	-0,6997	-0,4109	-0,4415
8	Linkages	0,32845	0,40149	0,3352	0,34184
9	Performance and structure of the economy	0,88934	1,20142	0,82315	0,85624
10	Sales impacts	0,05539	0,15682	0,10532	0,11186

$$\begin{aligned}AttractiveResearchSystems_{it} &= a_1 + b_1(BuyerSophistication)_{it} \\ &+ b_2(EnterpriseBirthsWithMoreThan10Employees)_{it} \\ &+ b_3(EmploymentFastGrowingEnterprisesOfInnovativeSectors)_{it} \\ &+ b_4(NonR\&DInnovationExpenditure)_{it} + b_5(R\&DExpenditureBusinessSector)_{it} \\ &+ b_6(BasicSchoolEntrepreneurialEducationAndTraining)_{it} \\ &+ b_7(EaseOfStartingABusiness)_{it} \\ &+ b_8(GovernmentProcurementOfAdvancedTechnologyProducts)_{it} \\ &+ b_9(RuleOfLaw)_{it} + b_{10}(NewDoctorateGraduates)_{it} \\ &+ b_{11}(TertiaryEducation)_{it} + b_{12}(InnovationIndex)_{it} \\ &+ b_{13}(MarketingOrOrganizationalInnovators)_{it} \\ &+ b_{14}(SMEInnovatingInHouse)_{it} + b_{15}(InnovativeSMEsCollaborating)_{it} \\ &+ b_{16}(PublicPrivateCoPublications)_{it} \\ &+ b_{17}(EmploymentShareManufacturing)_{it} \\ &+ b_{18}(ShareHighAndMediumHighTechManufacturing)_{it} \\ &+ b_{19}(ShareKnowledgeIntensiveServices\%)_{it} \\ &+ b_{20}(TurnoverShareLargeEnteprises)_{it} \\ &+ b_{21}(MediumAndHighTechProductExports)_{it}\end{aligned}$$

Since

$$BusinessAndEntrepreneurship_{it} = a_1 + b_1(BuyerSophistication)_{it} + b_2(EnterpriseBirths)_{it}$$

$$\begin{aligned}EmploymentImpacts_{it} &= a_1 + b_1(EmploymentFastGrowingEnterprisesOfInnovativeSectors)_{it} \\ FirmInvestments_{it} &= a_1 + b_1(NonR\&DInnovationExpenditure)_{it} \\ &+ b_2(R\&DExpenditureBusinessSector)_{it}\end{aligned}$$

$$\begin{aligned}GovernanceAndPolicyFramework_{it} &= a_1 + b_1(BasiSchoolEntrepreneurialEducationAndTraining)_{it} \\ &+ b_2(EaseOfStartingABusiness)_{it} \\ &+ b_3(GovernmentProcurementOfAdvancedTechnologyProducts)_{it} \\ &+ b_4(RuleOfLaw)_{it}\end{aligned}$$

$$HumanResources_{it} = a_1 + b_1(NewDoctorateGraduates)_{it} + b_2(TertiaryEducation)_{it}$$

$$\begin{aligned}Innovators_{it} &= a_1 + b_1(MarketingOrOrganisationalInnovators)_{it} \\ &+ b_2(SMEsInnovatingInHouse)_{it}\end{aligned}$$

$$Linkages_{it} = a_1 + b_1(InnovativeSMEsCollaborating)_{it} + b_2(PublicPrivateCoPublications)_{it}$$

$$\begin{aligned}PerformanceAndStructureOfTheEconomy_{it} &= a_1 + b_1(EmploymentShareManufacturing)_{it} \\ &+ b_2(ShareHighAndMediumHIghTechManufacturing)_{it} \\ &+ b_3(ShareKnowledgeIntensiveServices)_{it} \\ &+ b_4(TurnoverShareLargeEnterprises)_{it}\end{aligned}$$

$$SalesImpacts_{it} = a_1 + b_1(MediumAndHighTechProductExports)_{it}$$

We have that

$$AttractiveResearchSystems_{it} = a_1 + b_1(BusinessAndEntrepreneurship)_{it} + b_2(EmploymentImpacts)_{it} + b_3(FirmInvestments)_{it} + b_4(GovernanceAndPolicyFramework)_{it} + b_5(HumanResources)_{it} + b_6(Innovators)_{it} + b_7(InnovationIndex)_{it} + b_8(Linkages)_{it} + b_9(PerformanceAndStructureOfTheEconomy)_{it} + b_{10}(SalesImpacts)_{it}$$

Synthesis of the regressions								
	WLS		Pooled OLS		Fixed Effects		Random Effects	
Coefficient	-0,0885978		1,34474		0,46644		0,538141	
A4	-0,195197	***	-0,2054	***	-0,1578	**	-0,163249	***
A6	8,31898	***	10,6708	**	5,34877	*	5,83347	**
A8	-0,463184	***	-0,69409	***	-0,3297	**	-0,359116	***
A9	-0,238081	***	-0,35183	***	-0,2304	***	-0,246423	***
A12	0,623037	***	0,81807	***	0,68767	***	0,708421	***
A15	-0,17063	***	-0,16251	***	-0,1084	***	-0,11657	***
A22	-2,57858	***	-2,84657	***	-1,9972	***	-2,10838	***
A24	2,43535	***	2,52484	***	1,78994	***	1,87683	***
A27	0,0443191	***	0,10058	***	0,05258	**	0,0580535	**
A34	-0,228265	***	-0,31478	***	-0,1868	***	-0,196701	***
A35	0,0553856	**	0,15682	***	0,10532	**	0,111862	**
A37	-0,048637	**	-0,1307	***	-0,0747	*	-0,081897	**
A38	-0,154334	***	-0,13965	***	-0,115	***	-0,119938	***
A45	0,284131	***	0,3009	***	0,28262	***	0,283782	***
A46	-0,581802	***	-0,51496	***	-0,295	***	-0,316213	***
A48	0,667491	***	0,68555	***	0,49869	***	0,529229	***
A50	-0,775197	***	-0,89673	***	-0,6465	***	-0,687387	***
A51	0,626551	***	0,86001	***	0,4083	**	0,456095	**
A52	-0,300901	***	-0,38489	***	-0,224	***	-0,244846	***
A53	-0,161399	***	-0,18769	***	-0,0569	*	-0,071535	**
A57	0,414952	***	0,42007	***	0,37373	***	0,379112	***

Beta	Variables	WLS	POOLED OLS	FIXED EFFECS	RANDOM EFFECTS
1	Business and entrepreneurship	8,14835	10,5083	5,24036	5,7169
2	Employment impacts	-0,2381	-0,3518	-0,2304	-0,2464
3	Firm investments	-0,7361	-0,6546	-0,41	-0,4362
4	Governance and policy framework	-2,5695	-3,0605	-1,986	-2,1015
5	Human resources	-0,21	-0,3184	-0,1316	-0,1534
6	Innovation index	2,43535	2,52484	1,78994	1,87683
7	Innovators	-0,5292	-0,6997	-0,4109	-0,4415
8	Linkages	0,32845	0,40149	0,3352	0,34184
9	Performance and structure of the economy	0,88934	1,20142	0,82315	0,85624
10	Sales impacts	0,05539	0,15682	0,10532	0,11186

A1	Attractive research systems		Y	
A6	Buyer sophistication (SD)	1	BUSINESS AND ENTREPRENEURSHIP	1
A15	Enterprise births (10+ employees) (SD)	2	BUSINESS AND ENTREPRENEURSHIP	
A9	Employment fast-growing enterprises of	3	Employment impacts	2

	innovative sectors			
A38	*Non-R&D innovation expenditure*	*4*	*Firm investments*	*3*
A46	*R&D expenditure business sector*	*5*	*Firm investments*	
A4	*Basic-school entrepreneurial education and training (SD)*	*6*	*GOVERNANCE AND POLICY FRAMEWORK*	*4*
A8	*Ease of starting a business (SD)*	*7*	*GOVERNANCE AND POLICY FRAMEWORK*	
A22	*Government procurement of advanced technology products (SD)*	*8*	*GOVERNANCE AND POLICY FRAMEWORK*	
A48	*Rule of law (SD)*	*9*	*GOVERNANCE AND POLICY FRAMEWORK*	
A37	*New doctorate graduates*	*10*	*Human resources*	*5*
A53	*Tertiary education*	*11*	*Human resources*	
A24	*Innovation index*	*12*	*Innovation index*	*6*
A34	*Marketing or organisational innovators*	*13*	*Innovators*	*7*
A52	*SMEs innovating in-house*	*14*	*Innovators*	
A27	*Innovative SMEs collaborating*	*15*	*Linkages*	*8*
A45	*Public-private co-publications*	*16*	*Linkages*	
A12	*Employment share Manufacturing (SD)*	*17*	*PERFORMANCE AND STRUCTURE OF THE ECONOMY*	*9*
A50	*Share High and Medium high-tech manufacturing (SD)*	*18*	*PERFORMANCE AND STRUCTURE OF THE ECONOMY*	
A51	*Share Knowledge-intensive services (%) (SD)*	*19*	*PERFORMANCE AND STRUCTURE OF THE ECONOMY*	
A57	*Turnover share large enterprises (SD)*	*20*	*PERFORMANCE AND STRUCTURE OF THE ECONOMY*	
A35	*Medium and high-tech product exports*	*21*	*Sales impacts*	*10*

Descriptive statistics, using observations (1: 01-36: 10)

Variable	Mean	Median	Minimum	Maximum
A1	82,970	63,785	0,0000	261,75
A4	4,2286	0,0000	0,0000	211,00
A6	0,74535	0,0000	0,0000	5,0167
A8	14,917	0,0000	0,0000	85,013
A9	67,492	54,640	0,0000	204,82
A12	4,4794	0,0000	0,0000	117,01
A15	96,325	96,154	0,0000	253,85
A22	4,3792	0,0000	0,0000	183,97
A24	79,379	78,183	0,0000	329,62
A27	100,14	92,311	0,0000	316,29
A34	66,631	73,334	0,0000	163,44
A35	64,574	72,434	0,0000	163,44
A37	75,186	63,374	0,0000	249,48
A38	81,640	82,511	0,0000	250,20
A45	95,518	54,699	0,0000	367,29
A46	67,460	43,741	0,0000	367,29
A48	6,1413	0,0000	-0,76374	92,715
A50	10,806	0,0000	0,0000	78,921
A51	6,4135	0,0000	0,0000	59,778
A52	61,211	58,235	0,0000	170,00
A53	100,28	85,537	0,0000	274,38
A57	7,1965	0,0000	0,0000	83,537

Variable	Standard Deviation	Coeff. Of variation	Asymmetry	Kurtosis
A1	76,463	0,92157	0,61151	-0,84805
A4	26,088	6,1694	6,7039	44,009
A6	1,5219	2,0419	1,6411	0,91791
A8	30,210	2,0251	1,5395	0,39862
A9	62,477	0,92569	0,49089	-0,95423
A12	12,883	2,8761	5,3358	35,741

A15	78,186	0,81169	0,19383	-1,1612
A22	24,031	5,4875	6,4562	40,202
A24	61,450	0,77414	1,2721	3,9698
A27	83,722	0,83607	0,52818	-0,68775
A34	49,665	0,74538	-0,028084	-1,2132
A35	49,809	0,77134	0,0024529	-1,2096
A37	65,650	0,87316	0,62306	-0,47785
A38	72,737	0,89095	0,56137	-0,52878
A45	110,48	1,1567	1,1683	0,14118
A46	72,489	1,0745	1,4581	2,3635
A48	18,346	2,9873	3,2151	9,3353
A50	20,530	1,9000	1,8006	2,0052
A51	13,896	2,1667	1,8382	1,7947
A52	51,704	0,84468	0,24155	-1,2619
A53	86,011	0,85767	0,24590	-1,2552
A57	17,486	2,4298	2,5506	6,1650
Variable	5%	95%	Range	Missing observations
A1	0,0000	217,69	131,43	0
A4	0,0000	2,4322	0,0000	0
A6	0,0000	4,3745	0,0000	0
A8	0,0000	79,445	0,0000	0
A9	0,0000	178,52	119,32	0
A12	0,0000	20,193	0,0000	0
A15	0,0000	238,08	161,54	0
A22	0,0000	4,0707	0,0000	0
A24	0,0000	152,14	78,346	0
A27	0,0000	262,45	130,46	0
A34	0,0000	142,21	97,715	0
A35	0,0000	142,98	103,82	0
A37	0,0000	200,30	109,46	0
A38	0,0000	238,23	125,78	0
A45	0,0000	344,15	151,19	0
A46	0,0000	191,43	100,17	0
A48	0,0000	56,015	0,85821	0
A50	0,0000	60,345	12,726	0
A51	0,0000	38,999	0,0000	0
A52	0,0000	141,69	108,99	0
A53	0,0000	255,37	170,66	0
A57	0,0000	43,564	0,0000	0

WLS, using 360 observations					
36 cross section units included					
Dependent variable: A1					
Weights based on variances of errors per unit					
	Coefficient	*Standard Err.*	*t*	*p-value*	
const	−0,0885978	1,15965	−0,07640	0,9391	
A4	−0,195197	0,0193372	−10,09	<0,0001	***
A6	8,31898	2,13557	3,895	0,0001	***
A8	−0,463184	0,106245	−4,360	<0,0001	***
A9	−0,238081	0,0187454	−12,70	<0,0001	***
A12	0,623037	0,0581070	10,72	<0,0001	***
A15	−0,170630	0,0140356	−12,16	<0,0001	***
A22	−2,57858	0,117518	−21,94	<0,0001	***
A24	2,43535	0,0880119	27,67	<0,0001	***
A27	0,0443191	0,0149818	2,958	0,0033	***
A34	−0,228265	0,0389412	−5,862	<0,0001	***

A35	0,0553856	0,0266326	2,080	0,0383	**
A37	−0,0486370	0,0207831	−2,340	0,0199	**
A38	−0,154334	0,0109048	−14,15	<0,0001	***
A45	0,284131	0,0172205	16,50	<0,0001	***
A46	−0,581802	0,0345284	−16,85	<0,0001	***
A48	0,667491	0,0509654	13,10	<0,0001	***
A50	−0,775197	0,0492618	−15,74	<0,0001	***
A51	0,626551	0,119918	5,225	<0,0001	***
A52	−0,300901	0,0325028	−9,258	<0,0001	***
A53	−0,161399	0,0177229	−9,107	<0,0001	***
A57	0,414952	0,0433938	9,562	<0,0001	***
Statistics based on weighted data:					
Standard deviation	281,4027	*Standard Error*	0,912443		
R-squared	0,978549	*R-squared correct*	0,977216		
F(21, 338)	734,2329	*P-value(F)*	1,5e-267		
Log-likelihood	−466,4807	*Akaike's criterion*	976,9615		
Schwarz's criterion	1062,456	*Hannan-Quinn*	1010,956		
Statistics based on original data:					
Mean dependent variable	82,97043	*Standard Err. Dependent Variable*	76,46322		
quadratic sum of residuals	164432,7	*Standard Error Regression*	22,05646		

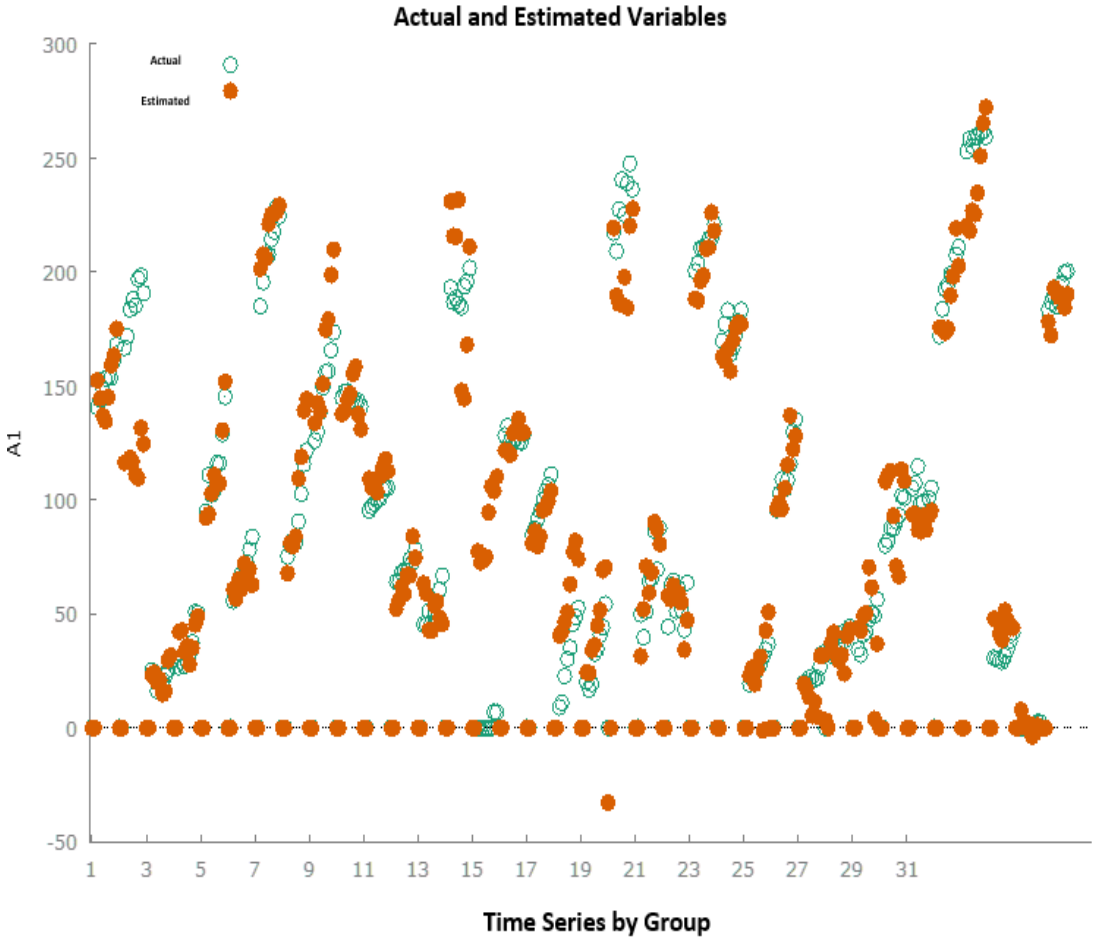

Figure1. Actual and estimated value in the WLS model.

Pooled OLS, using 360 observations					
36 cross section units included					
Time series length = 10					
Dependent variable:A1					
	Coefficient	*Std.Error*	*t*	*p-value*	
const	1,34474	2,33559	0,5758	0,5652	
A4	−0,205399	0,0506604	−4,054	<0,0001	***
A6	10,6708	4,17269	2,557	0,0110	**
A8	−0,694094	0,183088	−3,791	0,0002	***
A9	−0,351828	0,0313219	−11,23	<0,0001	***
A12	0,818074	0,109550	7,468	<0,0001	***
A15	−0,162511	0,0228281	−7,119	<0,0001	***
A22	−2,84657	0,160967	−17,68	<0,0001	***
A24	2,52484	0,129053	19,56	<0,0001	***
A27	0,100583	0,0281373	3,575	0,0004	***
A34	−0,314775	0,0627456	−5,017	<0,0001	***
A35	0,156820	0,0480529	3,263	0,0012	***
A37	−0,130697	0,0355558	−3,676	0,0003	***
A38	−0,139653	0,0204186	−6,839	<0,0001	***
A45	0,300904	0,0306968	9,802	<0,0001	***
A46	−0,514964	0,0535341	−9,619	<0,0001	***
A48	0,685552	0,0969454	7,072	<0,0001	***
A50	−0,896732	0,0950753	−9,432	<0,0001	***
A51	0,860006	0,272835	3,152	0,0018	***
A52	−0,384893	0,0592670	−6,494	<0,0001	***
A53	−0,187690	0,0282546	−6,643	<0,0001	***
A57	0,420074	0,0909061	4,621	<0,0001	***

Mean Dependent Variable	82,97043	*Standard Error Dependent Variable*	76,46322
Residual Sum of Squares	147452,5	*Standard Error Regression*	20,88660
R-squared	0,929749	*R-squared correct*	0,925384
F(21, 338)	213,0151	*P-value(F)*	1,1e-180
Log-likelihood	−1593,546	*Akaike's Criterion*	3231,092
Schwarz's Criterion	3316,587	*Hannan-Quinn*	3265,087
rho	0,809383	*Durbin-Watson*	0,456989

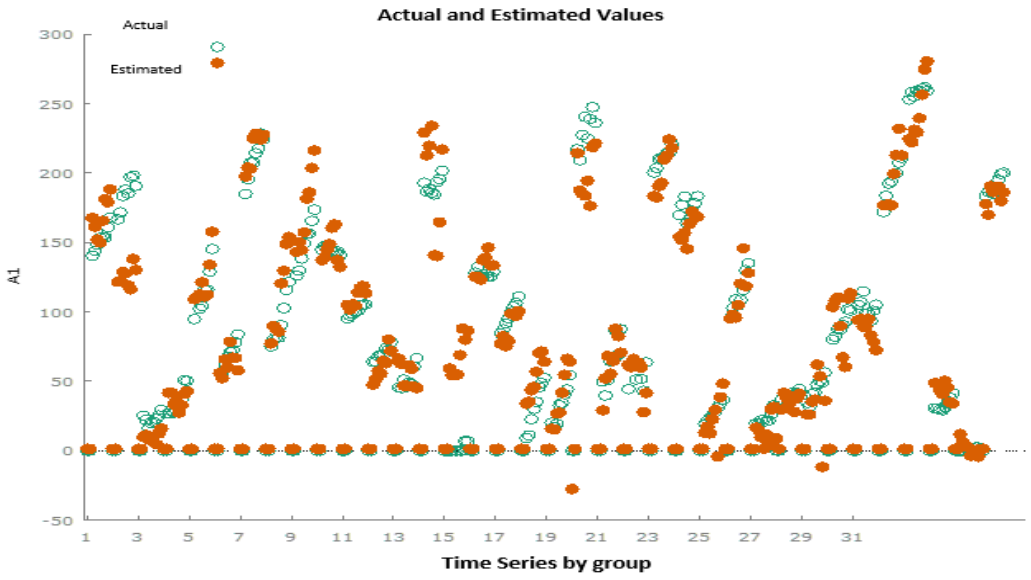

Figure 2. Actual and estimated values OLS.

Fixed Effects, using 360 observations
36 cross section units included
Time series length = 10
Dependent variable: A1

	Coefficient	*Std. Error*	*t*	*p-value*	
const	0,466438	1,53176	0,3045	0,7609	
A4	−0,157818	0,0622756	−2,534	0,0118	**
A6	5,34877	2,84670	1,879	0,0612	*
A8	−0,329650	0,128016	−2,575	0,0105	**
A9	−0,230398	0,0332808	−6,923	<0,0001	***
A12	0,687669	0,120949	5,686	<0,0001	***
A15	−0,108406	0,0257860	−4,204	<0,0001	***
A22	−1,99724	0,166649	−11,98	<0,0001	***
A24	1,78994	0,123752	14,46	<0,0001	***
A27	0,0525843	0,0266782	1,971	0,0496	**
A34	−0,186843	0,0598983	−3,119	0,0020	***
A35	0,105318	0,0532973	1,976	0,0491	**
A37	−0,0746791	0,0383765	−1,946	0,0526	*
A38	−0,114994	0,0210969	−5,451	<0,0001	***
A45	0,282618	0,0331577	8,523	<0,0001	***
A46	−0,294976	0,0513701	−5,742	<0,0001	***
A48	0,498690	0,110617	4,508	<0,0001	***
A50	−0,646547	0,100792	−6,415	<0,0001	***
A51	0,408297	0,195697	2,086	0,0378	**
A52	−0,224042	0,0549175	−4,080	<0,0001	***
A53	−0,0568758	0,0301865	−1,884	0,0605	*
A57	0,373733	0,0899979	4,153	<0,0001	***

Mean Dependent Variable	82,97043	*Standard Error Dependent Variable*	76,46322
Residual Sum of Squares	53503,59	*Standard Error Regression*	13,28832
R-squared LSDV	0,974509	*R-squared intra-groups*	0,942776
LSDV F(56, 303)	206,8508	*P-value(F)*	1,3e-210
Log-likelihood	−1411,070	*Akaike's Criterion*	2936,140
Schwarz's Criterion	3157,648	*Hannan-Quinn*	3024,216
rho	0,438991	*Durbin-Watson*	0,894647

TestStatistics : F(21, 303) = 237,712
p-value = P(F(21, 303) > 237,712) = 2,14528e-174
Joint test on regressors
Group Intercept Difference Test -
Null hypothesis: groups have a common intercept
Test statistics:F(35, 303) = 15,2014
p-value = P(F(35, 303) > 15,2014) = 3,46743e-048

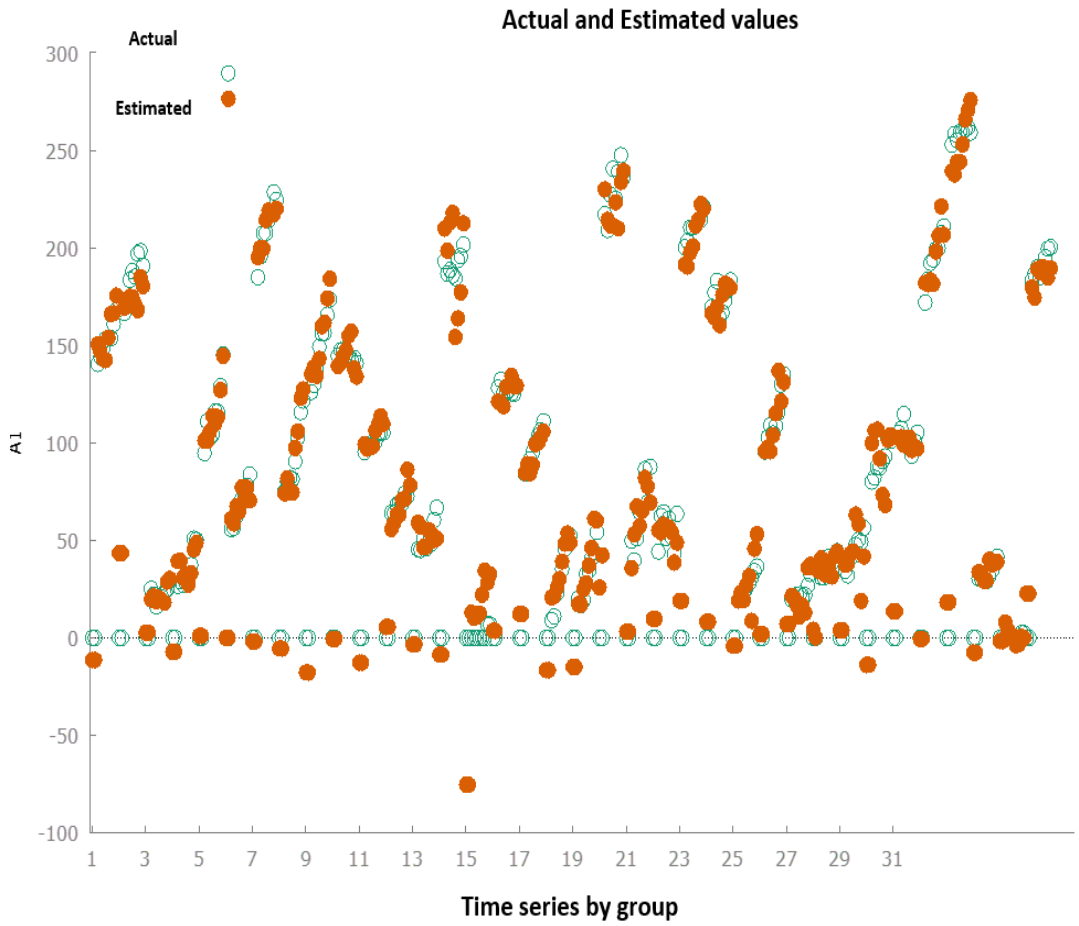

Figure 3. Actual and Estimated Values in the model with fixed effects

Random Effects, using 360 observations					
36 cross sectional units included					
Time series length = 10					
Dependent variable:A1					
	Coefficient	*Std.Error*	*z*	*p-value*	
const	0,538141	3,35844	0,1602	0,8727	
A4	-0,163249	0,0578097	-2,824	0,0047	***
A6	5,83347	2,83472	2,058	0,0396	**
A8	-0,359116	0,127098	-2,826	0,0047	***
A9	-0,246423	0,0317162	-7,770	<0,0001	***
A12	0,708421	0,114891	6,166	<0,0001	***
A15	-0,116570	0,0243034	-4,796	<0,0001	***
A22	-2,10838	0,158959	-13,26	<0,0001	***
A24	1,87683	0,119443	15,71	<0,0001	***
A27	0,0580535	0,0257993	2,250	0,0244	**
A34	-0,196701	0,0579406	-3,395	0,0007	***
A35	0,111862	0,0505310	2,214	0,0268	**
A37	-0,0818969	0,0366128	-2,237	0,0253	**
A38	-0,119938	0,0201946	-5,939	<0,0001	***
A45	0,283782	0,0314204	9,032	<0,0001	***
A46	-0,316213	0,0496483	-6,369	<0,0001	***
A48	0,529229	0,104132	5,082	<0,0001	***
A50	-0,687387	0,0960682	-7,155	<0,0001	***
A51	0,456095	0,193639	2,355	0,0185	**

A52	-0,244846	0,0533284	-4,591	<0,0001	***
A53	-0,0715350	0,0286180	-2,500	0,0124	**
A57	0,379112	0,0867130	4,372	<0,0001	***

Mean Dependent Variable	82,97043	Standard Error Dependent Variable	76,46322
Residual Sum of Squares	172752,6	Standard Error Regression	22,57420
Log-likelihood	-1622,050	Akaike's Criterion	3288,100
Schwarz's criterion	3373,594	Hannan-Quinn	3322,094
rho	0,438991	Durbin-Watson	0,894647

Variance 'between' = 320,362
Variance 'within' = 176,58
Theta used for transformation= 0,771441

Joint test on regressors -
Asymptotic Test Statistics: Chi-quadro(21) = 5278,44
p-value = 0

Test Breusch-Pagan -
Null hypothesis: variance of unit-specific error = 0
Asymptotic Test Statistics:Chi-quadro(1) = 396,632
p-value = 2,97955e-088

Test di Hausman -
Null hypothesis: GLS estimates are consistent
Asymptotic Test Statistics:Chi-quadro(21) = 25,4105
p-value = 0,229824

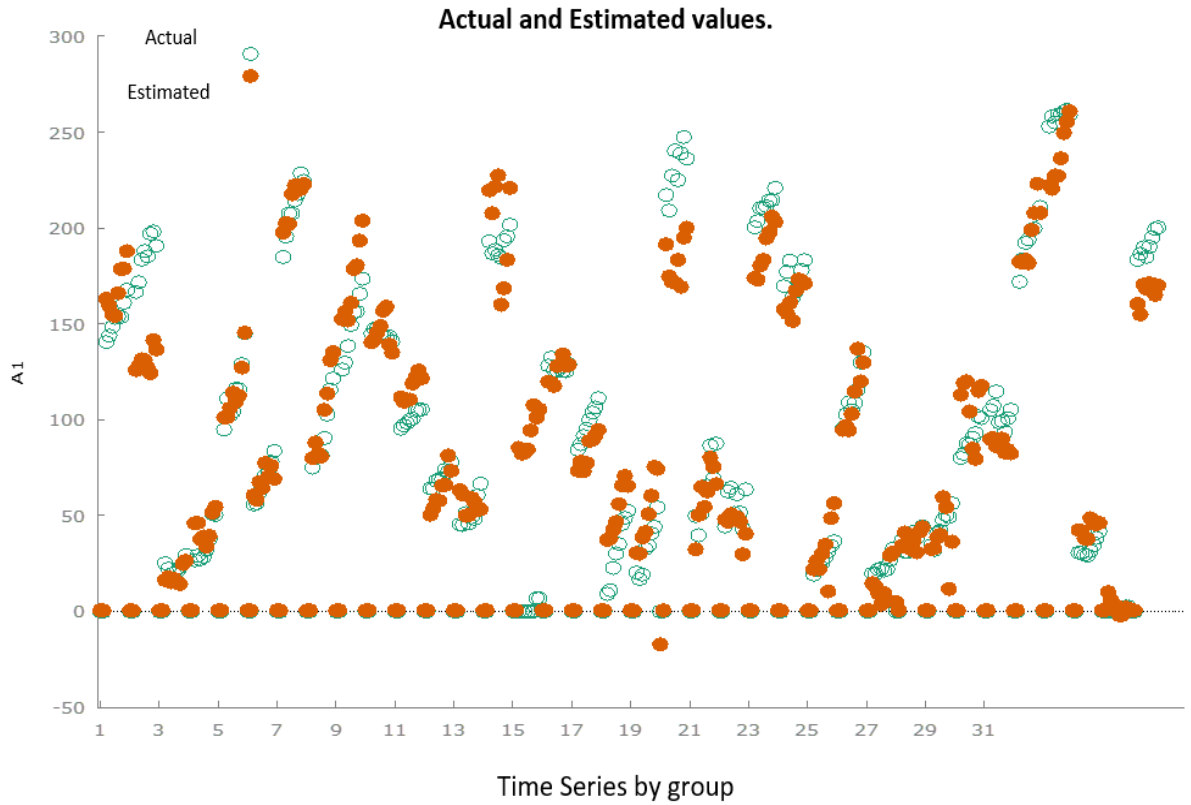

Figure 4. Actual and Estimated Value for Panel Data with Random Effects.

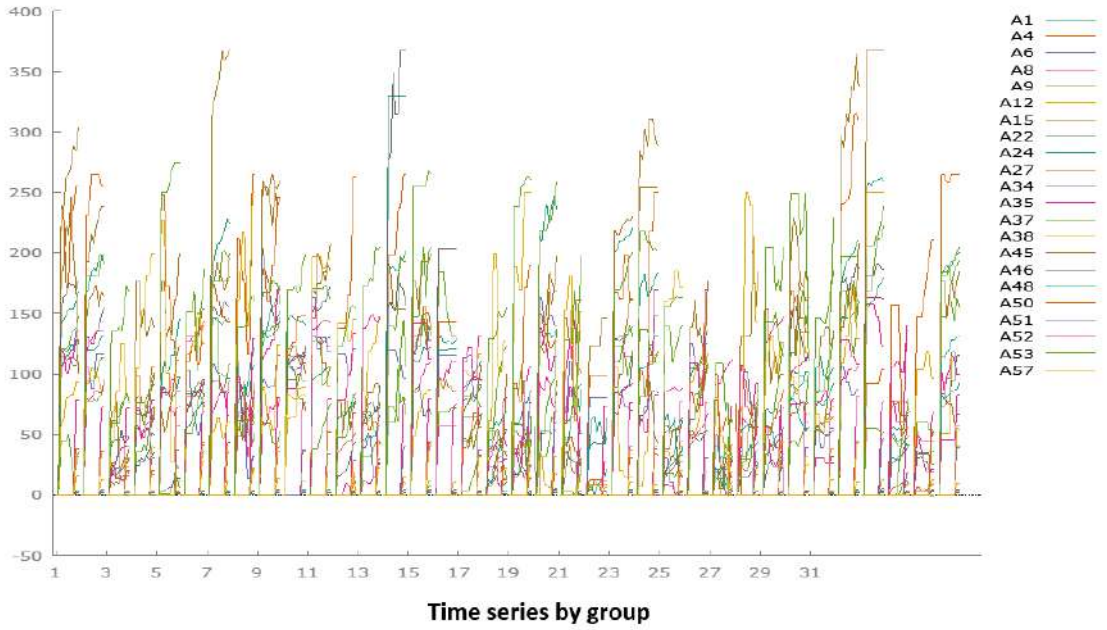

Figure 5: Time Series By Group.

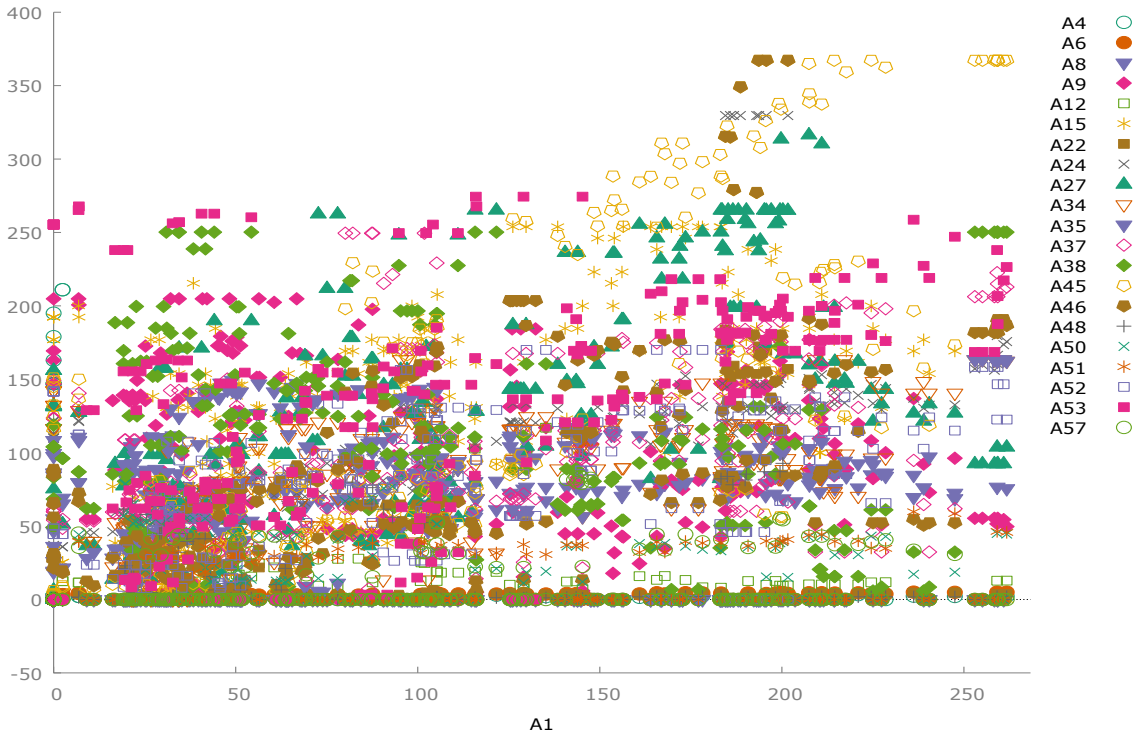

Figure 6. Scatter plot.

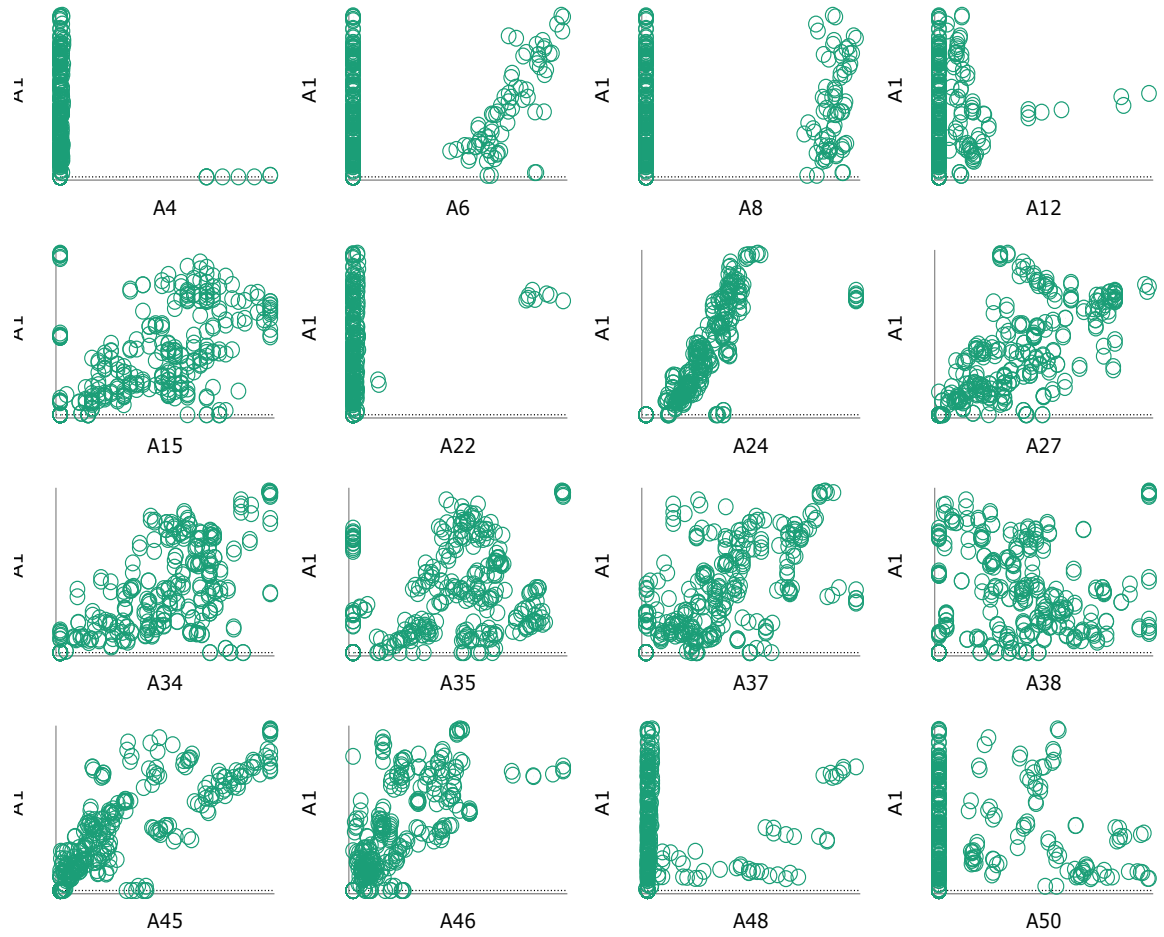

Figura 7. Scatter Chart Variables.

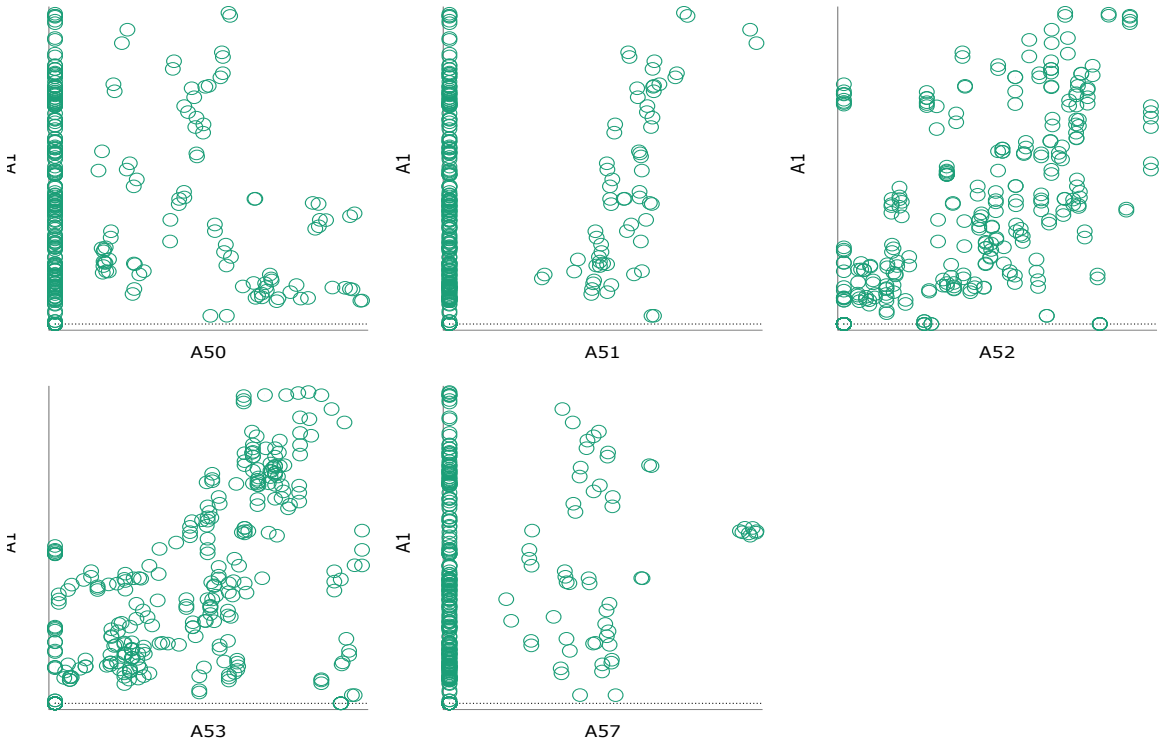

Figure 8.Scatter Chart Variables.

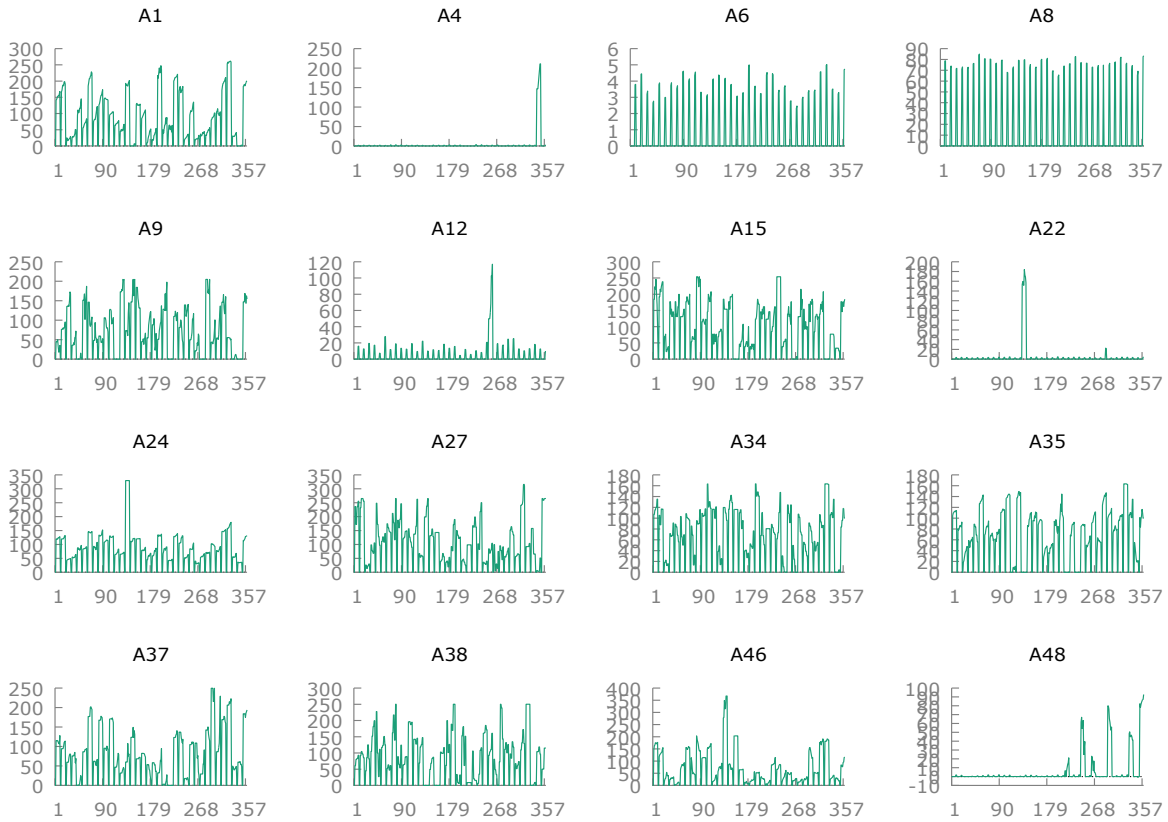

Figure 9. Time Series.

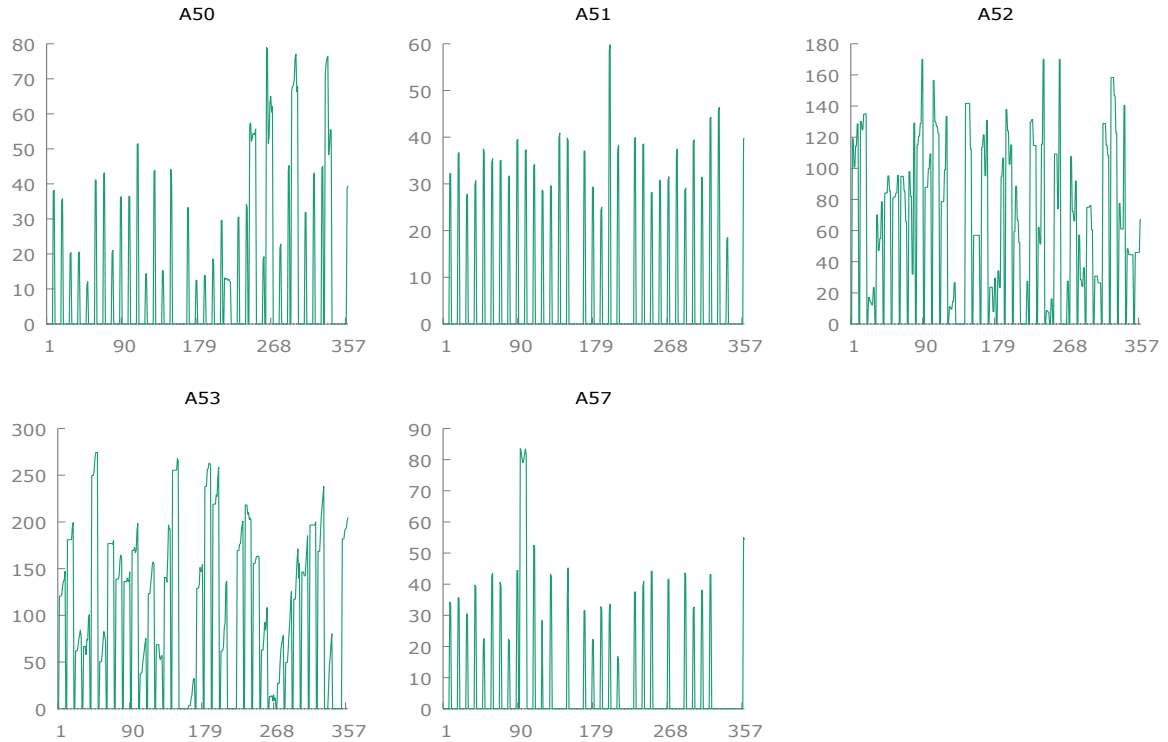

Figura 10. Time Series.

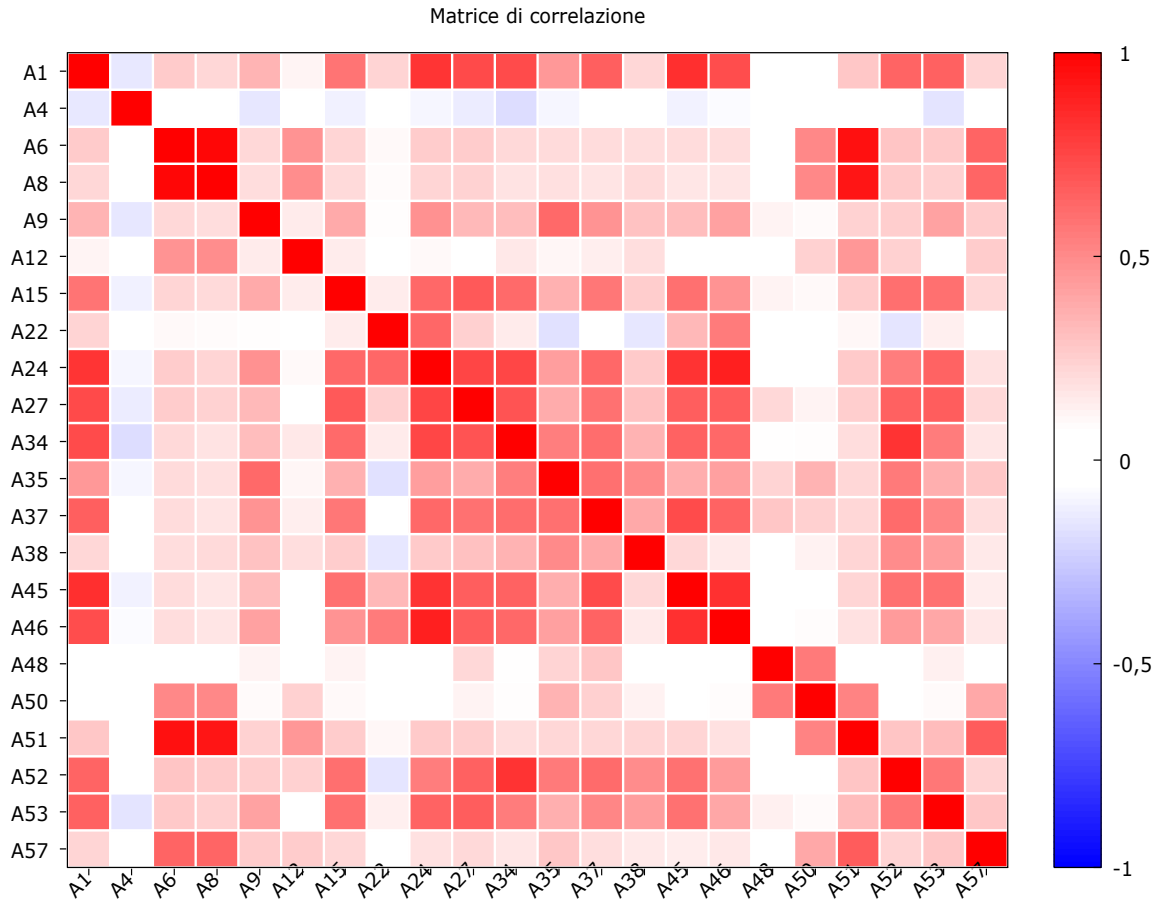

Figure 11. Correlation matrix.

Principal Component Analysis			
n = 360			
Analysis of the eigenvalues of the correlation matrix			
Component	Eigenvalue	Cumulative Proportion	
1	8,2961	0,3771	0,3771
2	3,4761	0,1580	0,5351
3	1,9262	0,0876	0,6227
4	1,5015	0,0682	0,6909
5	1,0577	0,0481	0,7390
6	1,0254	0,0466	0,7856
7	0,8317	0,0378	0,8234
8	0,7549	0,0343	0,8577
9	0,6476	0,0294	0,8871
10	0,4905	0,0223	0,9094
11	0,4124	0,0187	0,9282
12	0,4054	0,0184	0,9466
13	0,3128	0,0142	0,9608
14	0,2227	0,0101	0,9710
15	0,2028	0,0092	0,9802
16	0,1192	0,0054	0,9856
17	0,1056	0,0048	0,9904
18	0,0864	0,0039	0,9943
19	0,0567	0,0026	0,9969
20	0,0435	0,0020	0,9989
21	0,0183	0,0008	0,9997

22	0,0064	0,0003	1,0000				
Eigenvectors (component weights)							
	PC1	PC2	PC3	PC4	PC5	PC6	PC7
A1	-0,291	-0,136	0,082	-0,043	0,032	0,120	-0,030
A4	0,050	0,053	0,021	-0,170	-0,875	-0,098	-0,211
A6	-0,174	0,426	0,153	-0,072	-0,026	0,031	-0,067
A8	-0,163	0,436	0,147	-0,076	-0,029	0,025	-0,041
A9	-0,188	-0,000	-0,146	0,114	0,208	-0,654	-0,053
A12	-0,088	0,269	0,011	-0,189	-0,024	-0,047	0,781
A15	-0,253	-0,083	-0,031	-0,041	0,069	0,201	-0,021
A22	-0,085	-0,097	0,577	0,202	-0,086	-0,204	0,143
A24	-0,301	-0,157	0,235	0,060	-0,057	-0,120	0,052
A27	-0,282	-0,115	0,033	0,041	-0,003	0,254	-0,074
A34	-0,280	-0,132	-0,073	-0,098	0,034	0,172	0,203
A35	-0,218	0,009	-0,389	0,106	-0,003	-0,353	0,015
A37	-0,270	-0,089	-0,182	0,116	-0,177	-0,030	0,034
A38	-0,154	0,044	-0,353	-0,222	-0,171	-0,198	0,017
A45	-0,280	-0,178	0,152	-0,023	-0,057	0,050	-0,086
A46	-0,266	-0,168	0,245	0,137	-0,122	-0,189	0,062
A48	-0,052	0,064	-0,227	0,655	-0,157	0,244	0,067
A50	-0,098	0,318	-0,116	0,469	-0,105	0,137	0,076
A51	-0,179	0,418	0,140	-0,060	0,068	0,022	-0,089
A52	-0,264	-0,049	-0,223	-0,317	-0,055	0,228	0,095
A53	-0,255	-0,057	-0,059	-0,062	0,148	0,125	-0,287
A57	-0,145	0,327	0,037	-0,036	0,167	-0,071	-0,378
	PC8	PC9	PC10	PC11	PC12	PC13	PC14
A1	-0,161	0,057	-0,186	-0,313	-0,255	-0,107	-0,110
A4	0,044	0,268	0,128	-0,061	-0,061	-0,163	0,042
A6	-0,030	-0,025	-0,049	0,165	-0,256	0,091	-0,096
A8	-0,002	-0,030	-0,041	0,168	-0,220	0,135	-0,062
A9	0,138	0,375	-0,006	0,119	-0,220	0,024	0,073
A12	0,115	0,269	-0,121	-0,311	0,127	-0,073	0,159
A15	0,231	0,451	0,173	0,505	0,434	0,006	-0,155
A22	0,277	-0,203	0,197	-0,003	0,149	-0,106	-0,130
A24	0,096	-0,079	0,106	-0,038	-0,031	-0,113	-0,071
A27	0,182	0,059	0,193	-0,049	-0,165	0,444	0,632
A34	-0,118	-0,124	0,420	-0,004	-0,160	-0,102	-0,377
A35	-0,249	-0,125	0,254	0,046	-0,091	-0,234	0,075
A37	-0,212	0,137	-0,439	0,003	0,234	0,201	-0,198
A38	0,443	-0,550	-0,114	-0,010	0,216	0,295	-0,107
A45	-0,239	-0,063	-0,406	0,088	0,155	-0,093	0,049
A46	-0,238	-0,107	0,001	-0,027	0,042	0,254	0,151
A48	0,216	0,124	0,016	-0,214	-0,201	0,188	-0,321
A50	-0,112	-0,230	0,021	0,179	0,256	-0,376	0,370
A51	0,002	-0,059	-0,120	0,162	-0,099	-0,011	-0,117
A52	-0,141	-0,057	0,201	0,048	-0,061	-0,076	0,068
A53	0,480	0,014	-0,237	-0,231	-0,082	-0,496	0,102
A57	-0,160	0,112	0,299	-0,551	0,477	0,120	-0,073
	PC15	PC16	PC17	PC18	PC19	PC20	PC21
A1	0,576	0,100	0,339	0,113	-0,187	-0,250	0,003
A4	0,011	0,075	0,061	-0,012	0,086	0,042	-0,020
A6	-0,018	-0,041	-0,056	-0,184	-0,133	-0,033	0,757
A8	-0,013	-0,054	-0,155	-0,297	-0,396	0,025	-0,607

A9	-0,188	0,362	0,130	0,155	-0,101	0,029	0,007
A12	0,059	-0,003	-0,076	-0,064	0,077	0,085	0,017
A15	0,316	-0,011	-0,070	-0,079	0,017	-0,113	0,021
A22	-0,067	-0,261	0,054	0,231	-0,199	0,170	0,081
A24	0,000	-0,015	0,069	0,026	-0,103	-0,176	-0,121
A27	-0,004	-0,148	0,232	-0,012	0,053	0,236	0,009
A34	-0,279	0,254	0,273	-0,327	0,230	0,198	-0,029
A35	0,333	-0,501	-0,180	-0,095	0,066	0,212	0,014
A37	-0,394	-0,422	0,316	-0,043	-0,076	-0,079	-0,002
A38	0,181	0,186	0,065	-0,003	-0,024	-0,026	0,028
A45	0,077	0,317	-0,252	0,037	-0,036	0,637	0,026
A46	-0,035	0,142	-0,422	-0,196	0,343	-0,466	-0,007
A48	0,051	0,080	-0,303	0,153	0,008	0,104	0,002
A50	-0,051	0,263	0,262	-0,016	-0,099	-0,163	0,003
A51	0,041	-0,097	0,134	0,463	0,642	0,033	-0,180
A52	-0,284	0,012	-0,310	0,575	-0,299	-0,174	0,031
A53	-0,229	-0,139	-0,197	-0,225	0,132	-0,099	0,004
A57	-0,036	0,071	-0,022	0,013	-0,057	0,065	0,015

	PC22
A1	-0,235
A4	-0,033
A6	0,092
A8	-0,104
A9	-0,098
A12	0,032
A15	-0,050
A22	-0,359
A24	0,835
A27	0,007
A34	-0,129
A35	-0,005
A37	-0,036
A38	-0,030
A45	0,067
A46	-0,195
A48	0,041
A50	-0,045
A51	0,027
A52	-0,076
A53	-0,115
A57	0,031

Figure Index