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The Impact of R&D Investments on Corporate Performance in European Countries

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ABSTRACT :In our article we analyze the determinants of investment in research and development in European industries. Data are collected from the Economics ofIndustrial Research & Innovation of EuropeanCommission for 23 countries in the period between 2003 and 2019. We apply panel data with fixed and random effects to estimate the impact of the research and development investment on the performance of the firm. We found that the investment in research and development is associated to an increase in net sales and the number of employees and to a decrease in the level of market capitalization and capital expenditures.

I. INTRODUCTION

In our analysis we consider the role of investment in research and development in European industries in the period 2003-2019. We collect data from the Institute of Research Industry[4] (Eurostat, 2020)for 39 industrial sectors. Research and development investment isinterpreted as one of the main tools to generate economic growth and to drive the real economy toward its potential path (Schumpeter, 2013). In effect either in the work of Solow (Solow, 1956) based on the idea of the knowledge as a tool to generate economic growth either in the theory of Joseph Schumpeter (Reinert & Reinert, 2006) there are explicit reference to the role of innovation and research and development in the process of value production. In particular in the economic theory the development of an approach based on knowledge can be traced back in the economic theory of Hayek (Von Hayek, 1937). Certainly, the question of knowledge and its role in the economic sphere can be considered as a tool that has been introduced in the second part of the XX century (Arena, et al., 2012).

Knowledge economics and the economics of information. The development of the knowledge economics and the orientation to the knowledge society has increased its value during the fourth industrial revolution. The science of information has created an increasing debate about the possibility to consider the information as knowledge or as a basic entity that participate in the process of knowledge building. The development of knowledge economics can be considered as a particular evolution of the knowledge society (David & Foray, 2003). The fourth industrial revolution and the increasing level of capitalization of the economy has created a particular tension in respect to the role of technology. There is a connection among the development of information science, technology, economic growth and knowledge society. Technology drives economics growth. Technology is essentially based on the application of information science in the productive system in

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[4] We analyze data from the sequent countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Malta, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, The Netherlands, UK. The industrial sectors analyzed are: Aerospace & Defense , Alternative Energy, Automobiles & Parts, Banks, Beverages, Chemicals, Construction & Materials, Electricity, Electronic & Electrical Equipment, Financial Services, Fixed Line Telecommunications, Food & Drug Retailers, Food Producers, Forestry & Paper, Gas, Water & Multiutilities, General Industrials, General Retailers, Health Care Equipment & Services, Household Goods & Home Construction, Industrial Engineering, Industrial Metals & Mining, Leisure Goods, Life Insurance, Media, Mining, Mobile Telecommunications, Nonlife Insurance, Oil & Gas Producers, Oil Equipment, Services & Distribution, Personal Goods, Pharmaceuticals & Biotechnology, Real Estate Investment & Services, Software & Computer Services, Support Services, Technology Hardware & Equipment, Tobacco, Travel & Leisure.

the context of the Fourth Industrial Revolution. And the development of information science is the product of the knowledge society.

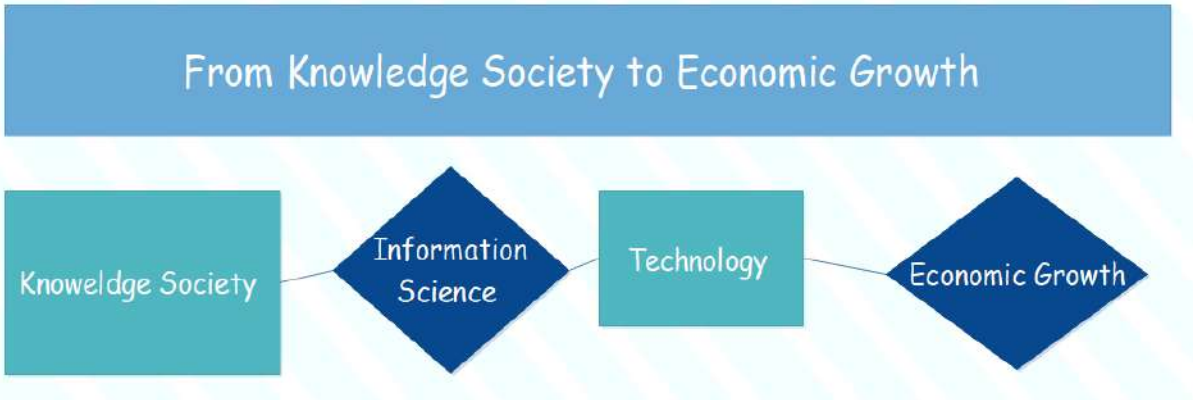

Figure 1. From Knowledge Society to Economic Growth. The Knowledge Society has created the incentives to develop the information science. Information science has produced the technology necessary to boost the economic growth.

The diffusion of technology among the firms and the economic organizations hasincreased the attention of scholars to the question of networks of knowledge. Networks of knowledge are relevant to determine the professional connection that can share innovation and technology. The nature of knowledge can be divided in two parts: tacit knowledge and explicit knowledge. Either tacit knowledge either explicit knowledge areessential to economic growth but whether explicit knowledge can be communicated formally, tacit knowledge cannot be easily extracted and diffused and requires strict human relationship among a certain professional community. While explicit knowledge does not require specifically a certain communitarian environment to be produced and can be learned either from non-members of professional and scientific communities, the tacit knowledge is relegated to personal relationships and requires the active participation of individuals to professional or scientific communities. The definition of tacit knowledge has been introduced by Micheal Polanyi (Polanyi, 2015). Tacit knowledge is a kind of knowledge that is embedded in the practices, in the behaviors and in the routines applied in a certain productive process. Tacit knowledge is a knowledge that is not possible to transfer neither with verbal form neither with written form. The development of tacit knowledge can be realized only producing goods and services.In this sense tacit knowledge can be considered as a form of learning by doing (Arrow, 1962).

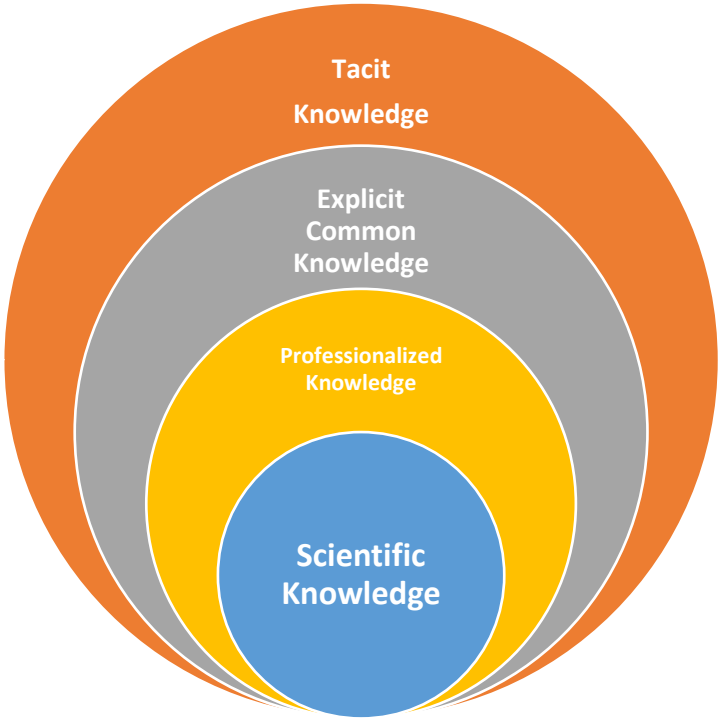

Figure 2. The relationship between Tacit knowledge, Explicit Common Knowledge, Professionalized Knowledge, Scientific Knowledge.

In the idea of Micheal Polanyi the tacit knowledge is greater than the knowledge that can be effectively communicated through language either verbally either in a written form (Polanyi, 2009). Explicit knowledge is based on the tacit knowledge. There are many forms and typologies of explicit knowledge that are based on the ability to formalize the language used for the communication. The level of specialization and formalization in the knowledge can be considered on a scale based on the ability to formalize information to pursue the ends of the communication. At the lower degree in the sense of communication there is Tacit Knowledge characterized by the impossibility to be transmitted either in written either in verbal forms, at the second degree there is Explicit Common Knowledge that is the expression of the main culture, later the Professionalized Knowledge and the Scientific Knowledge (Fig.3).

Figure 3. Typologies of knowledge based on the degree of communicability in written and verbal forms. Tacit knowledge has the lowest degree of communicability.

Even if tacit knowledge is embedded in explicit knowledge it is impossible to give an intelligible form to tacit knowledge. But in the economic literature the development of tacit knowledge can be considered as an approximation of learning by doing. Learning by doing in fact is characterized by a series of practices that are not transferable easily with verbal or written forms. Tacit knowledge is a sort of unaware kind of knowledge (Reber, 1989), in the sense that people is not aware to have tacit knowledge and they are not able to create formal tools to transfer tacit knowledge. But tacit knowledge and learning by doing are also able to generate relevant organizational changes (Lam, 2000). In particular, there is a large inefficiency in the communication process of the tacit knowledge, in the sense that people are not conscious of the methodologies that can be used to communicate the complex set of information and knowledge that is embedded in learning by doing. Tacit knowledge can increase the opportunities to improve creativity and the process of discovery of innovations (Seidler-de Alwis & Hartmann, 2008). To transfer tacit knowledge with informal tools, neither written neither verbal, it is necessary to increase the presence of personal interactions (Senker, 1995)and trust among the knowledge-holder i.e. the person or the group of persons that have tacit knowledge, and the knowledge-taker i.e. the persons or the group of persons that acquire tacit knowledge through learning by doing. Inter-personal relations can increase trust among co-workers that is necessary to share tacit knowledge (Holste & Fields, 2010). To improve the transfer of tacit knowledge it is important to develop methodologies able to create an efficient inter-personal communication process that let the knowledge flow from knowledge holders to knowledge takers. This kind of methodologies are generally associated to implicit contracts and informal organizational structures that are able to shape the productive process in the firm. Due to its characteristics tacit knowledge is relegated to the realm of small productive communities, professional (Baumard, 2002)and scientific groups. The impossibility to formalize the communication and transfer of tacit knowledge is an obstacle in respect to the possibility to create greater and deeper knowledge societies and networks. Know-how and learning by doing can be effectively considered as way to transfer knowledge that are based on non-formal communication and language neither written neither verbal. There are particular characteristics in the process of transferring tacit knowledge that are indicated as follows:

- **Intuition:** tacit knowledge cannot be manifested in the context of explicit and formalized forms of transmission. Since tacit knowledge is a form of non-verbal and non-written knowledge it can understood by intuition(Shirley & Langan-Fox, 1996)and observation. The knowledge-taker can extract information, practices and behavior from the knowledge-holders increasing the degree of personal relation in the productive act. The diffusion of tacit knowledge can be associated not only to the presence of scientific and professional skills but it can also be characterized by moods and sentiments that can be developed in the practice to sustain certain productive processes or to increase the level of efficiency of some organizations. The complex set of formal and informal skills, and the ability to realize a de-codification of the moods and sentiments that are characteristics of certain typologies of

work can effectively be better understood and captured through a continuative process of observation and practice of a certain science or profession. The act of observation, the complex set of inter-personal relations among knowledge-holder and knowledge-taker can facilitate the process of learning by intuition (Bennet & Bennet, 2008)i.e. the possibility to learn unconsciously without being aware of the learning processes. The learning process of tacit knowledge is embedded in the professional and scientific action of production and in the complex set of co-operation among the members of the productive community. In a certain sense the learning process of an implicit knowledge can be considered as learning process of a language that is acquired and exercised through the practice in a certain cultural and social environment even if the neophyte lacks of awareness about the cognitive process of learning.

- **Practice:**tacit knowledge is associated to practice. The possibility to transfer knowledge is effectively associated to the act of practicing. Practicing is really crucial in some professions, such as for example, intellectual and scientific professions(Imre, 1985), that are based on the cognition process and creation of routines and norms of acting. The diffusion of practices requires an active participation in the exercise of a certain profession or a certain ability or skills to extract the tacit knowledge. But either in this case, the possibility to understand and capture the best practices, is relegated to a certain community, a certain number of human relationships, a closed enclave of professionals and scientists. When a knowledge worker chooses a certain productive community to exercise her profession, she is choosing also a particular kind of tacit knowledge that can be learn only by practicing in that particular social environment.
- **Cooperation in the diffusion of knowledge:** the transfer of knowledge can be realized only increasing cooperation(Smith, 2001)and inter-personal relations among knowledge-takers and knowledge-holders. The learning process of tacit knowledge can be effectively realized only increasing the degree of cooperation(Lin, 2007) among the members of the professional and scientific community. Co-operation is not only a process of transferring knowledge but it is also a methodology that can create new knowledge, new practices and new efficient behavior.

Economics of Innovation. The economics of innovation in the context of economic growth has been introduced by Joseph Schumpeter (Scherer, 1986). In the idea of Schumpeter innovations are either technological, enterpreneurial and institutional. The possibility for the innovation to produce new results is based on the fact that these forces toghether operate to generate changes in the market and in the organization of the firms that we can consider as innovation. The process of innovation is not determined politically, but it can be realized through a set ofendogenous changes in the market. Capitalism is a continuous process of innovation that has an evolutionary side and that can create a process of creative-destruction (Caballero, 2010). The process of creative destruction can be considered as a mechanism by which the new innovation creates a new market either in the sense of production either in the sense of consumption. Innovations can produce new products and services and through this methodology they "*destroy*" old methodologies of production and final goods and services. The creative destruction is a process that characterize the entire system of evolution of capitalism. Creative destruction is a tool that can be used to explain business cycles and economic innovations. The economics of innovation is able to explain the determinants of the growth of economies overcoming the limitation of the classical analysis. The determinants of the economics of innovation are:

- *knowledge either tacit either codified*(Magnier-Watanabe & Benton, 2017)*;*
- *the presence of policies affecting the role of entrepreneurship and innovation*(Mazzucato, 2018)*;*
- *cooperation and externalities among firms in the form of joint ventures and tech-alliances;*
- *the structure of property rights such as for example expenditures and licenses;*
- *particular methodologies of organization of the firms among the market such as for example in the presence of clusters, and agglomeration.*

The economics of innovation contrasts in respect to the idea of mainstream economics for the fact that the process of economic growth is not explained with market price signals, productive factor accumulation and de-regulation, but at the contrary it is reconducted to the idea that knowledge, either in the form of Research and Development, either in the case of innovation, can increase the degree of production. The economics of innovation seems to be more able to describe the process of economic growth either in the economy as a whole either in the context of specific sector analysis. Mainstream economics is not able to shed light on the inner process of innovation and technological and scientific research that is able to boost productivity and income while the economics of innovation has the ability to describe the process of wealth accumulation and the struggle for change that is embedded in the production process. Mainstream economics is oriented to underline to role of market forces in producing innovation, while evolutionary economics recognize the role of policies in shaping the path toward a deeper process of innovation (Castellacci, 2008).

Knowledge as public good. Knowledge is technically a public good. Public goods are considered as characterized by non-rivalrousness, non-excludability(Stiglitz, 1999) and positive externalities. Non-rivalrousness consists in that there is a zero marginal costs in the fact that an additional individual or organization has access to a certain knowledge. The cost to produce knowledge for the umpteenth-consumer is equal to zero. There is no social benefit in the exclusion of some individuals from knowledge. Non-rivalrousness suggests that nobody should be excluded from knowledge. Non-excludability affirms that there is no probability to exclude some individual from knowledge. But in the case of industrial knowledge there is the probability for the firm to protect its discoveries with patents and secrets. In this case non-excludability is absent. Positive externalities instead are always an attribute of knowledge even in the case of patents and secrets.

II. LITERATURE REVIEW

In the sequent part we analyze the literature affecting the role of the economics of knowledge in the context of economic theory.

Institutional knowledge. (Greif & Laitin, 2004) afford the question of the institutional change. In particular the authors ask why institutions change, how institutions can persist in a complex environment and how the processes that are developed through the institutional change can destroy old practices and methodologies.Authors in particular analyze the role of learning and knowledge in the process of institutional building. Institutions can improve their efficiency by increasing their knowledge.

Learning by doing. (Jovanovic & Lach, 1989)afford the question of the role of knowledge in the relationships between new entrants and late entrants. Specifically, the authors say that late entrants have lower costs due to the presence of shared knowledge and learning by doing. Even if new entrants have generally higher incomes and they can obtain higher levels of profits, it is also true that they have to support the costs of extracting knowledge from the market. New entrants have higher risks, higher income and higher profits, while on the other side late entrants have lower risks, and lower profits due to the presence of learning by doing.

(Dasgupta && Stiglitz, 1988)analyzes the role of leaning by doing in production. The authors underlines that learning by doing involves sunk costs. But sunk costs are discretionary. Learning by doing can generate high profits even when there are new possibilities, such as for example new discoveries or new technologies, or when there is competition on the market. If the market is contestable the leading firm has declining profits. In fact, in a contestable market there is a higher probability for the new entrants to acquire knowledge and information about the methodologies of production. Learning by doing in this case is able to open the market to new competitors even in a zero-sum game among new entrants and market leaders. Learning by doing can also produce some sort of inefficiency especially in the case of entry costs even small, that can reduce the ability of new entrants to participate in the market. But even if, learning by doing can create the condition for a monopolistic market it can be very inefficient to put some limitation to the hegemonic to prevent the manifestation of centralized market in the sense of production.

(Greenwald & Stiglitz, 2013) afford the question of the role of innovation and research and development in the contest of industrial policy. Industrial policy is considered as a set of rules and institutional constraints that are able to determine an environment that is pro-active in respect to innovations. The authors in particular concentrate their attention in the process of production and dissemination of knowledge. The idea of knowledge is described as a public good. Public goods are characterized by the presence of positive externalities and of non-rivalry. Markets are in general inefficient in the production of public goods such as knowledge, and private sectors that are strongly dependent from public good offers can suffer from crisis and failures. Authors show that 70% of the increase in GDP per capita is associated to advances in technology. There is a large competition in the filling the gap with the technologies either among countries for the fact that countries with low knowledge try to acquire knowledge and technology from more advanced countries either in the same countries were productive communities and industries try to replicate the performance of above the average innovators.

The process of learning, and the determinants of learning, for their effect on technologies and innovations can become an essential part of the economic environment. Due to the fact that knowledge is able to shape GDP by the means of technologies there is a role to play for government and public policies to implement policies that are able to boost knowledge and innovations.

(Argote, et al., 1990) afford the question of the production and transfer of learning among organizations. Their analysis is based on data. The authors found that knowledge generated through production depreciates rapidly. In particular organizations that are second comers tend to be more efficient in respect to innovators. But the motivation that can sustain the accumulation processes of knowledge are not clear.

Accumulation of experiences. Workers in their ability to create and produce goods and services generate knowledge. This knowledge tends to increase in the same direction of the production processes. But it is difficult to found the exact shape of the accumulation of experience processes that is if the increasing. There are some points in which the accumulation of knowledge can be more than proportional, proportional or less than proportional in respect to the production of goods and services. In the fig. 4, inthe point A there is relation more

than proportional in the relation between knowledge and the production of goods and services, in the point B the relation is less than proportional, while in the point C there is a proportional relationship between knowledge and the production of goods and services. But the passages from points A, to B to C is realized with heuristics that are randomized and difficult to predict in the long run. The process of accumulation of knowledge depends from the production methodologies and technologies.The more the firm expands quantitatively and qualitatively its production the greater the knowledge that can be extracted and generated in the organization. But this process of knowledge creation based on the real productivity is non-linear.

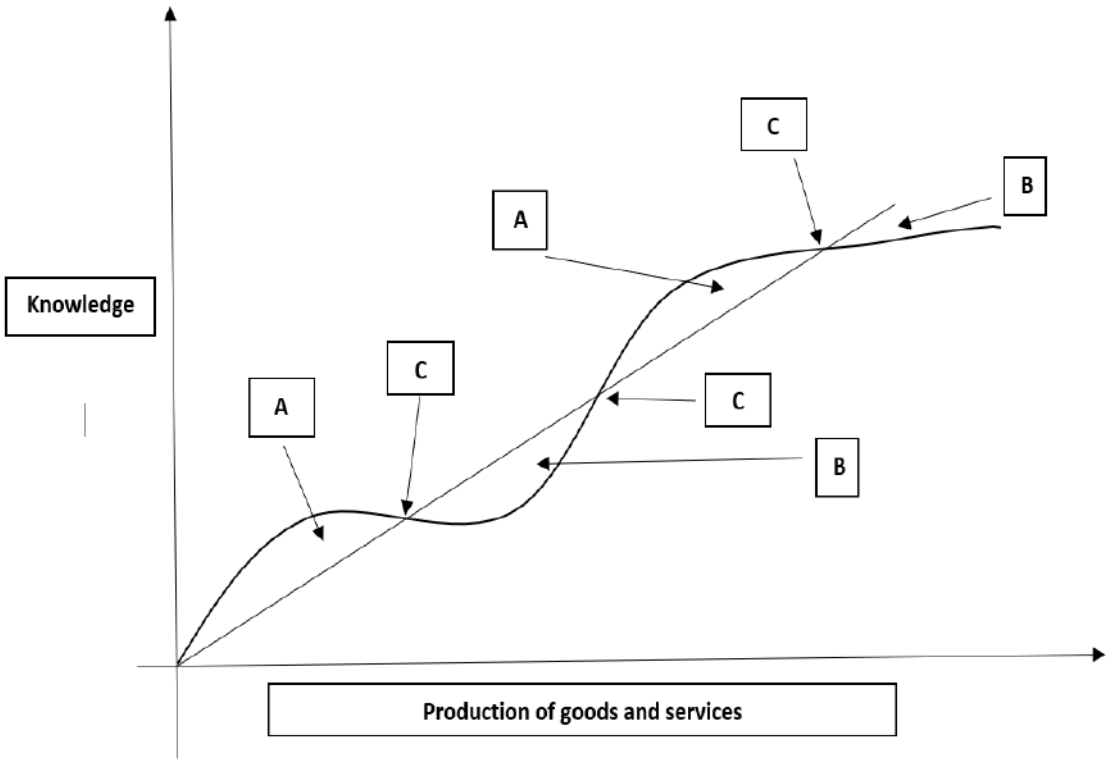

Figure 4. The relationship between knowledge e production of goods and services. The passages from points A, B and C is based on heuristics that are difficult to predict in the long run.

A In point A the level of knowledge accumulated is greater than the level of production of goods and services in unit. $\frac{\Delta Knowledge}{\Delta ProductionOfGoodAndServices} > 1$

B In point B the level of knowledge accumulated is lower than the level of production of goods and services in unit. $\frac{\Delta Knowledge}{\Delta ProductionOfGoodAndServices} < 1$

C In point C there the level of knowledge accumulated is greater than the level of production goods and services in unit. $\frac{\Delta Knowledge}{\Delta ProductionOfGoodAndServices} = 1$

Figure 5. Possible states of the relationship between knowledge and production of goods and services. In points A the level of knowledge accumulated is greater than the production of goods and services. In points B the level of knowledge accumulated is lower that the level of production of goods and services. In point C there is a perfect correspondence between the level of knowledge and the level of production of goods and services.

There are two element that are able to change the relationship between knowledge and the production of goods and services:

- **Increasing sophistication of capital equipment.** The development of knowledge through capital equipment is a possibility that depends substantially from the evolution of technology. The acquisition of new technological capital in the firm is able to realize new abilities among workers. In effect workers have to use new equipment with an increasing level of technological value of the production process. The increasing sophistication of capital equipment that is the evolution of new possibilities through the evolution of technology can change the process of value creation and can create the basis for the diffusion and the accumulation of new forms of knowldge. The possibility for the firm to improve the level of technology can produce a condition in which workers can increase the productive ability and can learn new methodology in the production process. The presence of a new equipment is associated with the increasing level of knowledge transferred and produced in the context of the production and can drive also towards a new process of creativity. The possibility to generate new knowledge with the usage of new equipment is important as a tool to determine new possibilities. The new equipment is able to generate new forms of knowledge, of innovation, and in a certain sense, this case can be reconducted to the precedent, since the new equipment can always be considered as a sort of increasing in building capacity. The possibility to realize new knowledge from the increase in capital equipment is a condition that can produce new characteristics.
- **Development of coordination among the production process:** the increase in coordination among different processes in the production area can increase the level of knowledge. Knowledge increases due to the presence of positive externalities that can be generated through the merge and coordination of processes (Simatupang, et al., 2002). The process of coordination can produce the collaboration among different workers from different departments. For example, in the development of cooperation among the department of production, marketing and finance there are positive spillovers that can generate an increase in knowledge. In this case the knowledge is not based on a specific activity of research and development but it is a sort of knowledge that can be considered as learning by doing. Learning by doing finally can produce positive externalities in the case of cooperation among different corporate departments.

Intellectual Property Rights-IPR.(Kremer & Williams, 2010)consider the role of technological progress in the context of economic growth. They found that to boost technological innovation it is important to protect intellectual property rights. Intellectual property rights have a twofold role in the process of generating knowledge and driving the economic growth. In particular property rights represent an incentive for firms and organizations to realize investments that are finalized in the process of innovations. In effect in the absence of intellectual property rights in effect firms do not have any incentive to innovate due to the fact that the result of the innovation process is not able to become a competitive advantage. And if innovation can be protected and used as a form of competitive advantage then there is no incentive for the firm to realize any form of investment. The presence of intellectual property rights is an incentive for firms to innovate. Firms can invest in new discoveries being sure that this kind of innovation can be effectively protected with adequate property rights. In the absence of intellectual property rights there is no incentive to invest and to realize new innovations especially in the context of perfect competition. In the case of perfect competition with no property rights, it is possible that the level of innovations and research and development outputs is under the social optimal equilibrium.The role of property rights can be considered in the sequent cases:

- *In perfect competition:* there is no possibility for the firm to realize an efficient investment in research and development, due to the fact that the absence of intellectual property rights, let every firm use the same products and services that have been developed in the R&D process. In the case of perfect competition, we can say that the level of innovation produced by the market is certainly sub-optimal and lower in respect to the potential level of feasible knowledge. The result is a reduction in the level of knowledge and technology and the decrease in the rate of economic growth.
- *In monopoly and oligopoly:* monopolies and oligopolies can have incentive to innovate even in the absence of propriety rights. The market structure of monopolies constitutes a sort of natural defense of the innovation. But at the same time, monopolies and oligopolies have lower incentives to innovate due to the presence of a market control and the absence of competition. So, in this case the absence of competition is either an incentive and a disincentive for the development of innovations in the case of monopoly. In effect monopolistic markets generally produce less innovation and knowledge than the regulated markets and more innovation and knowledge in respect to pure competitive markets (Stiglitz & Greenwald, 2014).

The best solution for the development of innovation and technologies in the contest of firms and innovation is based on the regulated market that is a competitive market characterized by the presence of intellectual propriety rights. Intellectual property rights can give the right incentive to innovate even in the case of competitive markets. Intellectual property rights are able to create the condition for the co-existence of competition and

innovation. But, even if the institutionalization of propriety rights does not solve the question of the modeling of the right incentive to create innovations and technology due to the fact that the duration of property rights can have an impact in the sense to increase or to reduce the efficiency of knowledge produced in the context of economic organizations. To solve the question of the efficient degree of intellectual property rights it is necessary to consider the legal and organizational condition of the market. Regulators can intervene to create the adequate condition to reduce the monopolistic and oligopolistic orientation of the market and to reduce the degree of competition trying to establishing a controlled market in which firms are remunerated for their ability to increase research and development.

Market structure and intellectual property rights. (Dasgupta & Stiglitz, 1980) analyze the role of research and development in respect to the market structure. The authors consider the question of competition and in particular they focalize their attention to the speed of research, the number of independent research laboratories, and the level of risk undertaken. The authors verify that the competition in the sense of current product market reduces the level of innovation. To improve the level of innovation and technology in the market it is necessary to introduce competition in the research and development sector. The presence of competition in the R&D sector is able to boost innovation in the society. The market structure is crucial to determinate the right level of innovation. On the other hand, the development of market excessively characterized by competition can reduce the level of innovation since the economic actors spends resources in the process of competition and do not have sufficient resources to improve the level of knowledge in the society.

Incentives to innovation. (Davis & Davis, 2004)shows that incentives to innovation in the form of prizes can have a relevant impact to create new research and development. The level of research and development generated by the society tends to be lower than the optimal equilibrium.

The dynamic of innovation. (Drandakis & Phelps, 1966)afford the question of technological innovation in the contest of economic growth. In particular the main idea of the authors is the fact that in the path of golden age output, consumption, investment and capital grew at the same rate. One of the main ideas of the article is the idea of the innovation possibility frontier. Firms can choose a certain level of innovation and can increase the level of knowledge over a certain frontier.

Innovation and institutions.(Filippetti & Archibugi, 2011)consider the role of innovation in respect to business cycles. The authors consider that in the context of the economic literature there are opposite definition of the role of the innovation in respect to the business cycle. In effect innovation can be considered either as a counter-cyclical force that increase during the recessions or as a cyclical determinant and the levels of investment in innovations decrease during the economic crisis. In this sense it is important to consider the question of the persistency of innovation. The persistency of innovation can be connected to two different dynamic:

- *It can be associated to firm specific characteristics:* in the case of firm specific characteristics, the development of the innovation is due to elements that are strictly related with the production function of the firm i.e. human capital, managerial choices, equipment, corporate culture and strategies. In this case the presence of the persistency is due to the economic, financial and human capital forces in the production function that can effectively create the conditions to develop structural innovation characterized by persistency. Firms can effectively invest their resources in permanent innovation methods, either booms either in depressions.
- *It can be related to macro-economic and social conditions:*The evolution of innovation and of research and development can be associated to macro-economic determinants that are able to explain the process of technological change. In this case even the development of technology and innovation can be explained as a generalized economic condition. When a firm insists in an environment characterized by the presence of a strong orientation to innovation, then the possibility to realize significant innovations either in the period of crisis can be considered effectively as a more feasible opportunity.
- *It can be related to the inner dynamic of a particular sector:* certain typology of firms can realize deep levels of innovation. Some sectors that have increasing returns and high levels of profits can be more efficient in the creation of innovations even during a crisis. For example, sectors that have a high degree of technological innovation can have greater ability to perform research and development activities either during a crisis.

More innovative economies and firms are characterized by a deeper persistent technological attitude. That's a kind of tautology in the sense that well performing economies are characterized by the presence of firms that realize deeper investments in research and development, and at the same time firms that invest more in research and development generally are located in innovative economies.

Authors refers to the presence of national institutions and organizations that are able to promote innovation and that can have an impact at the firm level, the national level and the international level. To develop a productive system oriented to persistent innovation it is necessary to create the right incentives for the firms but also to have an impact on an institutional level.

$$PersistentInnovation = EndogenousInnovation + ExogenousInnovation + InstitutionalEnvironment$$

- **Endogenous innovation:** is characterized by a series of innovation that are realized in the firm through the investment in research and development. Firms that area interested in the creation of new profitable opportunities, or firms that want to beat the concurrence can invest in research and development to acquire new market sources. Endogenous innovation is driven by managerial plan, and in particular there are many firms that can effectively be oriented to realize new and in particular innovative structure of inventions.In a vaster definition endogenous innovation can also be referred to the economy as a whole (Grossman & Helpman, 1994).
- **Exogenous innovation:** Exogenous innovation is characterized by the presence of incentives that are external to the firm and can create the conditions to perform innovation. It can be the case for example of public incentives that finance research and development or it can be the case of a particular market condition that can have the ability to remunerate investment in R&D. But exogenous innovation is also created by the presence of a sort of coordination among departments in a certain economic organization and among organizations in a certain market.
- **Institutional Environment:**the institutional environment is an essential part of the process of innovation and technology. In particular the presence of an institutional environment is characterized by the presence of laws and organizations that can improve the degree of the investment in the context of financial determinants. The presence of particular organizations that can improve knowledge such as for example National Systems of Innovation. The National Systems of Innovation is a model of institution and organizations that is based on the theory of National Innovation Systems. The idea of the presence of national innovation system is based on the presence of a network of organizations that include enterprises, universities, and public and private research institutes.

National systems of innovation. The idea, the practice, and the organizational theory of national system of innovation is applied to the study of the development and diffusion of knowledge and technology through the society as a whole. In the national system of innovation there is a strong interdependence among institutions, enterprises, and governments. The public and the private sectors toghether collaborate in the creation of new technology and innovations. In particular there is a strong connection between the business side of the equation and the presence of research that is realized in universities. Research institutes, universities, charities, corporations and governments can collaborate to create innovationand technologies than can be used to improve the development of the economic systems as a whole. The question of the actors that are involved in the context of research and development can be effectively considered especially in a multi-stakeholder approach (Ferri & Leogrande, 2015). The multi-stakeholder approach considers the possibility to create cooperation and a system of relations among various economic subjects interested in the development of knowledge. In particular the presence of an heterogenous set of institutions, organizations, and corporations either in private either in the public sphere can produce interactions and positive externalities. National innovation systems are considered as based on different kinds of informational flows i.e.:

1) ***interactions among enterprises:***firms realize joint ventures and alliances devoted to the production of new products and services for the market. In particular the possibility to create new complex projects that require active collaboration among firms, especially in different sectors, or in different points in the supply chain, create interactions among enterprises that can effectively produce innovations thanks to the creation of positive externalities among different typologies of economic organizations.
2) ***interactions among enterprises, universities and public research institutes:***create new knowledge and technological innovations that can be used for complex projects that serve not only the ends of the profit maximization but also the building process of public goods.
3) ***diffusion of knowledge and technology to enterprises:*** requires a series of organizations, infrastructures and institutions able to generate positive externalities and spillovers. There are many positive elements in the development of the diffusion of knowledge and technology in the enterprises due to fact that firms that can apply deeper technological knowledge have also the possibility to create better products and services for the market.
4) ***personnel mobility:***has an impact in the diffusion of knowledge.Human capital is depositary of knowledge. The allocation of human capital among different organizations, firms, institutions is able to shape the productive system. The mobility of human capital is correlated with the geography of innovations and the ability to promote technology.

III.THE MODEL

In our equation we estimate the Investment of Research and Development in respect to Net Sales, Employees, Market Capitalization and Capital Expenditures. Panel data either with fixed effects either with random effects are used. Results show that the increasing in Research and Development is associated to the increase in Net Sales, the increase in the number of employees, a reduction in Market Capitalization and a reduction in Capital Expenditures.

$$RDInvestment_{it} = a_1 + b_1(NetSales)_{it} + b_2(Employees)_{it} + b_3(MarketCapitalization)_{it} + b_4(CapitalExpenditures)_{it}$$

Descriptive statistics				
Variables	**Mean**	**Median**	**Minimum**	**Maximum**
RDInvestment	7594,7	2153,7	3,48	84318
NetSales	2,73E+05	91186	12	1,79E+06
Employees	8,86E+05	2,92E+05	0	7,17E+06
MarketCapitalization	2,38E+05	81565	0	1,99E+06
CapitalExpenditures	44608	526,97	0	4,44E+06
Variables	**Standard deviation**	**Coefficient of Variation**	**Asimmetry**	**Kurtosis**
RDInvestment	13338	1,7562	2,7978	8,9918
NetSales	4,49E+05	1,6451	1,9915	2,6688
Employees	1,53E+06	1,7232	2,1664	3,5257
MarketCapitalization	3,97E+05	1,6654	2,3294	4,9353
CapitalExpenditures	3,68E+05	8,2576	11,447	131,75
Variables	**5%**	**95%**	**Interquantile range**	**Missing values**
RDInvestment	17,668	37716	7416	61
NetSales	481,2	1,46E+06	2,40E+05	119
Employees	325,43	4,68E+06	8,26E+05	63
MarketCapitalization	377,9	1,26E+06	2,25E+05	156
CapitalExpenditures	9,5	81164	6000,8	80

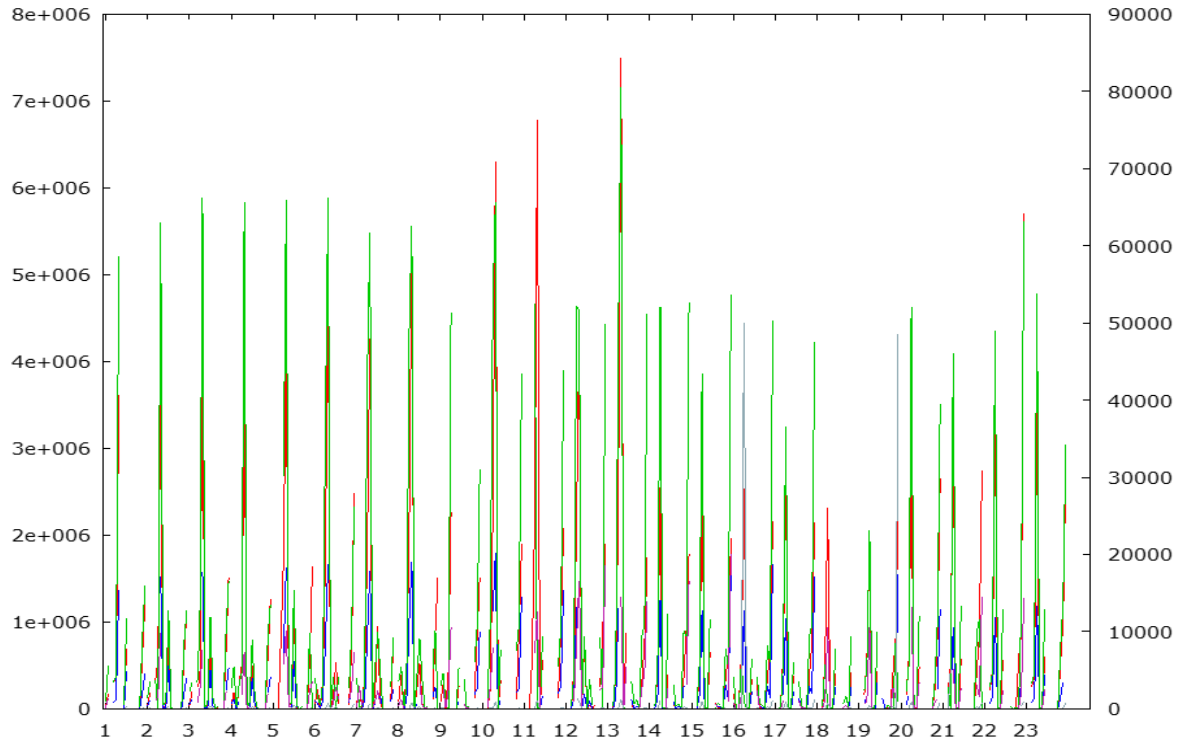

Figure 6. Group time series. Source: Economics of Industrial Research & Innovation of European Commission.

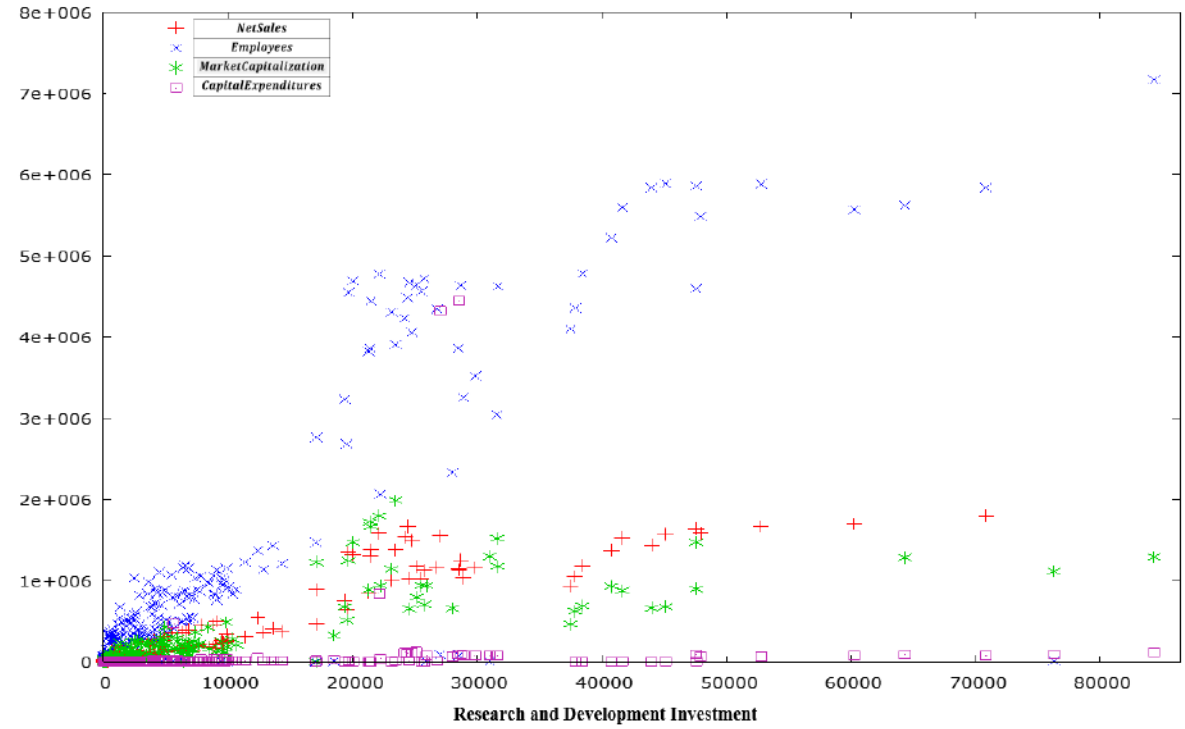

Figure 7. Scatter plot. Source: Economics of Industrial Research & Innovation of European Commission.

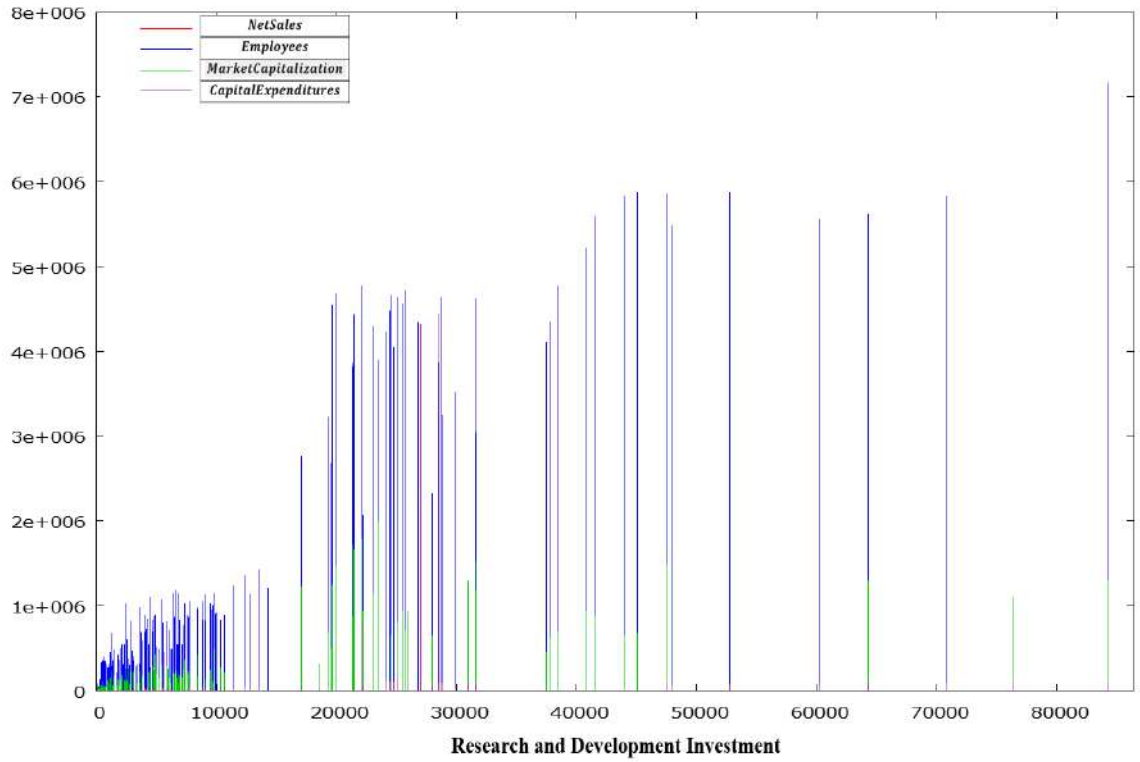

Figure 8. Pulse chart.Source: Economics of Industrial Research & Innovation of European Commission.

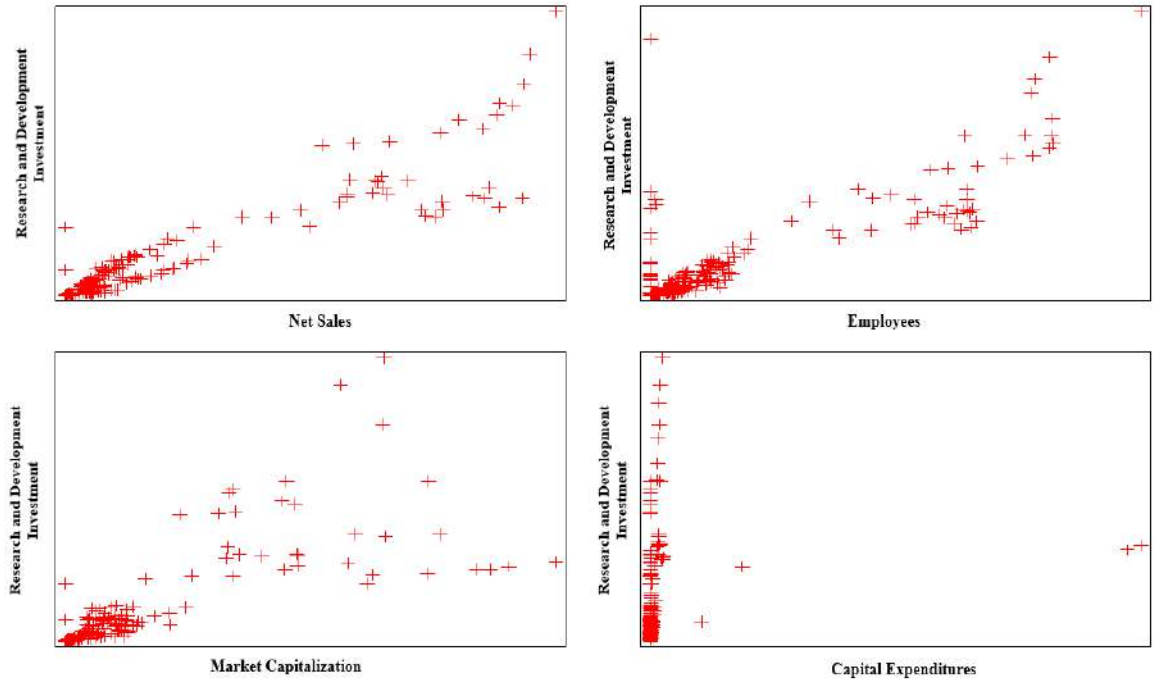

Figure 9. Multiple scatter plot. Source: Economics of Industrial Research & Innovation of European Commission.

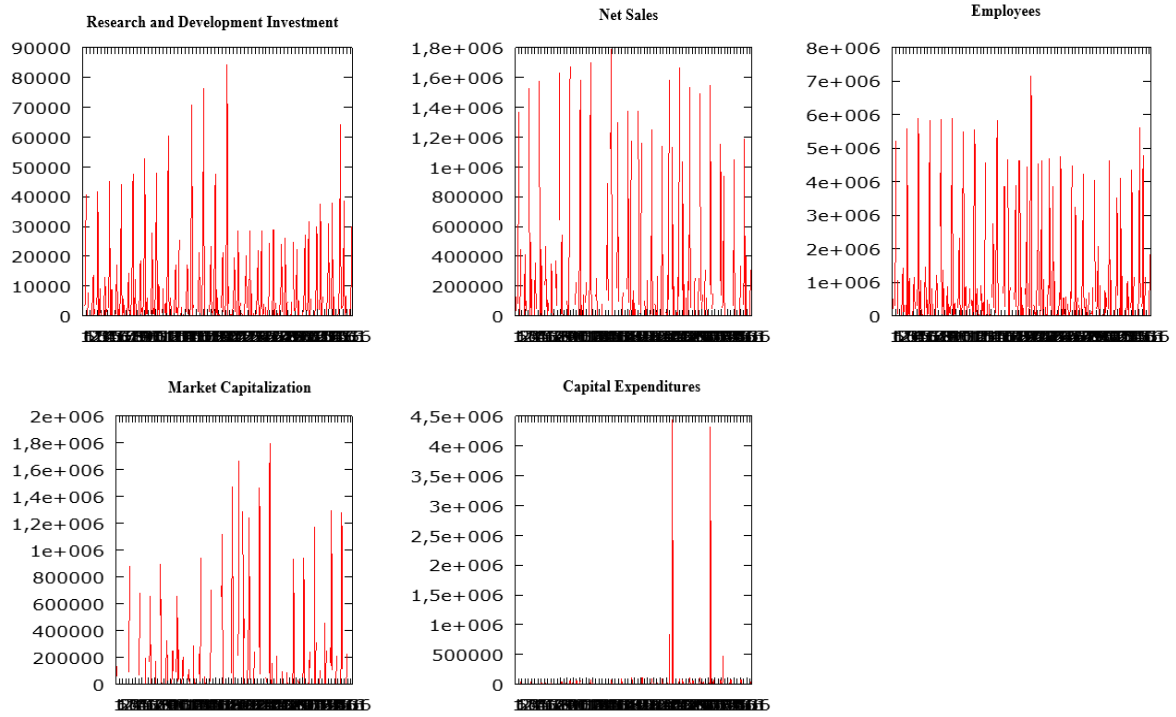

Figure 10. Time series. Source: Economics of Industrial Research & Innovation of European Commission.

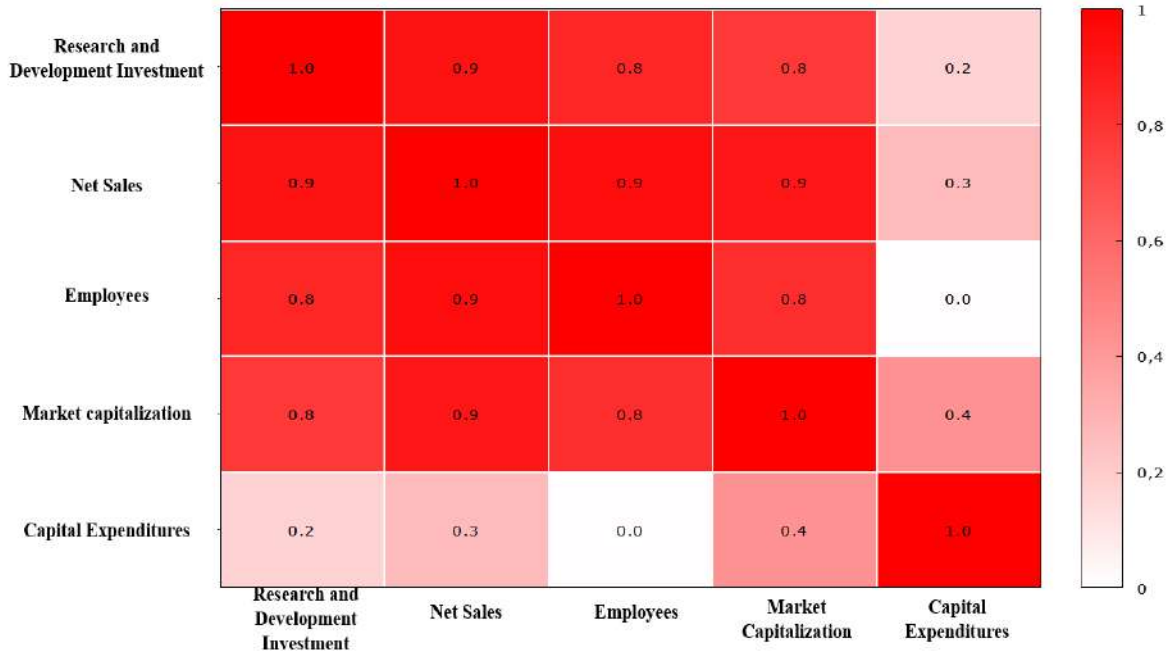

Figure 11. Correlation matrix.Source: Economics of Industrial Research & Innovation of European Commission.

Principal Component Analysis					
n = 139 (dropped 226 incomplete observations)					
Analysis of the eigenvalues of the correlation matrix					
Components	**Eigenvalue**	**Proportion**	**Cumulative**		
1	3,8175	0,7635	0,7635		
2	0,9363	0,1873	0,9507		

3	0,2208	0,0442	0,9949		
4	0,0196	0,0039	0,9988		
5	0,0059	0,0012	1		
Eigenvectors(component weights)					
	PC1	**PC2**	**PC3**	**PC4**	**PC5**
RDInvestment	0,48	0,227	-0,532	0,655	-0,073
NetSales	0,509	0,069	0,009	-0,3	0,804
Employees	0,503	0,134	-0,175	-0,62	-0,56
MarketCapitalization	0,472	-0,075	0,801	0,309	-0,187
CapitalExpenditures	0,183	-0,959	-0,212	0,022	-0,023

Dependent Variable: Research and Development Investments

Number of observations: 139, number of units 23, time series 5-8. Fixed Effects

	Coefficient	*Std. Error*	*T*	*p-value*	
const	62,0367	220,243	0,2817	0,7787	
Net Sales	0,0178001	0,00446814	3,984	0,0001	***
Employees	0,00401496	0,000982864	4,085	<0,0001	***
Market Capitalization	−0,0101928	0,00151928	−6,709	<0,0001	***
Capital Expenditures	−0,00962738	0,00318802	−3,020	0,0031	***

Mean Dependent Variable	6139,962	*SQM dependent variable*	10661,79
Sum residual squares	5,32e+08	*S.E. regression*	2178,899
R-squared LSDV	0,966104	*R-squared intra-group*	0,963708
LSDV F(26, 112)	122,7765	*P-value(F)*	2,37e-70
Log-likelihood	−1250,656	*Akaike Criterion*	2555,312
Schwarz Criterion	2634,543	*Hannan-Quinn*	2587,510
rho	0,384835	*Durbin-Watson*	0,814465

Joint test on regressors

*Test statistics:*F (4, 112) = 743,517

p-value = P(F(4, 112) > 743,517) = 1,22918e-079

Group Intercept Difference Test -

Null hypothesis: groups have a common intercept

*Test Statistics*F(22, 112) = 1,10111

p-value = P(F(22, 112) > 1,10111) = 0,356516

Dependent variable: Research and Development Investment. Panel data random effects

Number of observations 139, time series min5 max8, cross section units 23

	Coefficient	*Std. Error*	*z*	*p-value*	
const	158,490	219,089	0,7234	0,4694	
Net Sales	0,0202118	0,00427319	4,730	<0,0001	***
Employees	0,00366304	0,000949461	3,858	0,0001	***
Market Capitalization	-0,0119323	0,00141263	-8,447	<0,0001	***
Capital Expenditures	-0,00824857	0,00291286	-2,832	0,0046	***

	Dependent Variable Mean	6139,962	SQM dependent variable	10661,79
	Residual Sum of Square	6,47e+08	E.S. regression	2188,758
	Log-likelihood	-1264,265	Akaike Criterion	2538,529
	Schwarz Criterion	2553,202	Hannan-Quinn	2544,492
	rho	0,384835	Durbin-Watson	0,814465
Variance 'between' = 0				
Variance 'within' = 4,7476e+006				
theta medio = 0				

WLS-Weights based on variances of errors per unit

Observation 139, cross sections units,

	Coefficient	*Std. Error*	*t*	*p-value*	
Const	89,4216	157,671	0,5671	0,5716	
Net Sales	0,0184827	0,00315416	5,860	<0,0001	***
Employees	0,00411489	0,000762801	5,394	<0,0001	***
Market Capitalization	−0,0110742	0,00103632	−10,69	<0,0001	***
Capital Expenditures	−0,00852015	0,00193102	−4,412	<0,0001	***

Statistics based on weighted data

Residual Sum of Square	134,6889	*E.S. regression*	1,002567
R-squared	0,978245	*R-squared correct*	0,977596
F (4, 134)	1506,406	*P-value(F)*	2,7e-110
Log-likelihood	−195,0428	*Akaike Criterion*	400,0856
Schwarz Criterion	414,7579	*Hannan-Quinn*	406,0480

Statistics based on original data

Mean dependent variable	6139,962	*SQM dependent variable*	10661,79
Residual Sum of Squares	6,60e+08	*S.E. regression*	2219,953

IV. CONCLUSIONS

In our article we analyze the determinants of investment in research and development in European industries. Data are collected from Economics of Industrial Research & Innovation of European Commissionfor 23 countries in the period between 2003 and 2019. We apply panel data with fixed and random effects to estimate the impact of the research and development investment on the performance of the firms. Results show that investment in research and development is associated to an increase in net sales and in the number of employees and a decrease in the level of market capitalization and capital expenditures.

BIBLIOGRAPHY

[1]. Arena, R., Festré, A. & Lazaric, N., 2012. *Handbook of Knowledge and Economics.* s.l.:Edward Elgar Publishing.

[2]. Argote, L., Beckman, S. L. & Epple, D., 1990. The persistence and transfer of learning in industrial settings. *Management science,* 36(2), pp. 140-154.

[3]. Arrow, K. J., 1962. The Economic Implications of Learning by Doing. *The Review of Economic Studies,* 29(3), p. 155.

[4]. Baumard, P., 2002. Tacit knowledge in professional firms: the teachings of firms in very puzzling situations. *Journal of knowledge management.*

[5]. Bennet, D. & Bennet, A., 2008. Engaging tacit knowledge in support of organizational learning. *VINE,* 38(1).

[6]. Caballero, R. J., 2010. Creative destruction. In: *Economic Growth* . London: Palgrave Macmillan, pp. 24-29.

[7]. Castellacci, F., 2008. Innovation and the competitiveness of industries: Comparing the mainstream and the evolutionary approaches. *Technological Forecasting and Social Change,* 75(7), pp. 984-1006.

[8]. Dasgupta, P. && Stiglitz, J., 1988. Learning-by-doing, market structure and industrial and trade policies. *Oxford Economic Papers,* 40(2), pp. 246-268.

[9]. Dasgupta, P. & Stiglitz, J., 1980. Uncertainty, industrial structure, and the speed of R&D. *The Bell Journal of Economics*, pp. 1-28..

[10]. David, P. A. & Foray, D., 2003. Economic fundamentals of the knowledge society. *Policy futures in education*, 1(1), pp. 20-49.

[11]. Davis, L. & Davis, J., 2004. How effective are prizes as incentives to innovation?. *Evidence from three 20th century contests DRUID summer conference.*

[12]. Drandakis, E. M. & Phelps, E. S., 1966. A model of induced invention, growth and distribution. *The Economic Journal*, 76(304), pp. 823-840.

[13]. Eurostat, 2020. *Economics of Industrial Research and Innovation.* [Online]
Available at: https://iri.jrc.ec.europa.eu/data
[Consultato il giorno 11 06 2020].

[14]. Ferri, G. & Leogrande, A., 2015. Was the Crisis due to a shift from stakeholder to shareholder finance? Surveying the debate. *Money and Finance Research group (Mo. Fi. R.)-Univ. Politecnica Marche-Dept. Economic and Social Sciences*, Volume 108.

[15]. Filippetti, A. & Archibugi, D., 2011. Innovation in times of crisis: National Systems of Innovation, structure, and demand. *Research Policy*, Volume 179-192., p. 2.

[16]. Greenwald, B. & Stiglitz, J. E., 2013. Industrial policies, the creation of a learning society, and economic development. *The Industrial Policy Revolution I* , Palgrave Macmillan(London), pp. 43-71.

[17]. Greif, A. & Laitin, D. D., 2004. A theory of endogenous institutional change. *American political science review*, 4(98), pp. 633-652.

[18]. Holste, J. S. & Fields, D., 2010. Trust and tacit knowledge sharing and use. *Journal of knowledge management.*

[19]. Imre, R. W., 1985. Tacit knowledge in social work research and practice. *Smith College Studies in Social Work*, 55 (2), pp. 137-149.

[20]. Jovanovic, B. & Lach, S., 1989. Entry, exit, and diffusion with learning by doing. *The American Economic Review*, pp. 690-699.

[21]. Kremer, M. & Williams, H., 2010. Incentivizing innovation: Adding to the tool kit. *Innovation policy and the economy*, 10(1), pp. 1-17.

[22]. Lam, A., 2000. Tacit knowledge, organizational learning and societal institutions: An integrated framework. *Organization studies*, 21(3), pp. 487-513.

[23]. Lin, C. P., 2007. To share or not to share: Modeling tacit knowledge sharing, its mediators and antecedents. *Journal of business ethics*, 70(4), pp. 411-428.

[24]. Polanyi, M., 2009. *The tacit dimension.* University of Chicago press a cura di s.l.:s.n.

[25]. Polanyi, M., 2015. *Personal knowledge: Towards a post-critical philosophy.* s.l.: University of Chicago Press.

[26]. Reber, A. S., 1989. Implicit learning and tacit knowledge. *Journal of Experimental Psychology: General*, 118(3), p. 219–235.

[27]. Reinert, H. & Reinert, E. S., 2006. Creative destruction in economics: Nietzsche, Sombart, Schumpeter. In: *Friedrich Nietzsche (1844–1900)* . s.l.: Springer, Boston, MA., pp. 55-85.

[28]. Scherer, F. M., 1986. *Innovation and growth: Schumpeterian perspectives.* MIT Press Books, 1. a cura di s.l.:s.n.

[29]. Schumpeter, J. A., 2013. Capitalism, socialism and democracy. Volume routledge.

[30]. Seidler-de Alwis, R. & Hartmann, E., 2008. The use of tacit knowledge within innovative companies: knowledge management in innovative enterprises. *Journal of knowledge Management.*

[31]. Senker, J., 1995. Tacit knowledge and models of innovation. *Industrial and corporate change*, 4(2), pp. 425-447.

[32]. Shirley, D. A. & Langan-Fox, J., 1996. Intuition: A review of the literature. *Psychological Reports*, 79(2), pp. 563-584.

[33]. Smith, E. A., 2001. The role of tacit and explicit knowledge in the workplace. *Journal of knowledge Management.*

[34]. Solow, R. M., 1956. A contribution to the theory of economic growth. *The quarterly journal of economics*, 70(1), pp. 65-94.

[35]. Stiglitz, J. E., 1999. Knowledge as a global public good. *Global public goods: International cooperation in the 21st century,*, Volume 308, pp. 308-325.

[36]. Von Hayek, F. A., 1937. Economics and knowledge. *Economica*, 4(13), pp. 33-54.