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# The innovation-employment nexus in Europe

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**ABSTRACT :**The question of the determinants of employment in innovative firms in Europe is analyzed. We use data from European Innovation Scoreboard that consider 36 countries in the period 2000-2019. Results show that the level of employment for innovative firms is positively associated with "*Average annual population growth*", "*Basic-school entrepreneurial education and training*", "*Ease of starting a business*", "*Firm investments*"; "*Foreign controlled enterprises-share of value added",*"*Government procurement of advanced technology products*", "*Human resources", "Sales impacts*" and negatively associated with "*Buyer sophistication (SD)*", "*Linkages*".

## I. INTRODUCTION

The impact of employment in innovative firms in Europe is analyzed in this article.The "*Employment Impacts"* is considered constituted as the summation of "*Employment in knowledge-intensive activities*" and the "*Employment in fast-growing enterprises of innovative sectors*". These two elements can put in evidence the employment in high innovative sectors. Generally, the employment in knowledge intensive activities is based on human capital with high professional skills and competencies. Innovation and technological change are the product of human capital and knowledge. Knowledge and technology are both based on human capital. The role of human capital for the pursuit of economic growth has been emphasized either in Solow Growth Theory(Solow, 1956), either in the Endogenous Growth Theory (Romer, 1994)and in the context of Schumpeterian and innovation economics(Schumpeter, 2013). The role of knowledge has been recognized as a tool for growth. Knowledge is a good that is produced in connection with the enrichment of human capital, and with technology. Knowledge is an essential good for the economic growtheitherin developed countries eitherin non-developed countries. Employment in high performing countries is based on the presence of human capital with high skills, generally associated with tertiary education. But it is also relevant the role of firms and corporations in promoting the process of enrichment of human capital.

One of the main theories in explaining the complex relationship between innovation and employment is the compensation theory. The compensation theory is an ancient theory that can be traced back in the work of the French economist Jean Baptiste Say (Say, 1964), but also in the works of David Ricardo (Ricardo, 1951) and also Karl Marx (Marx, 1961). The compensation theory suggests that while some jobs disappear due to technological change at the same time other jobs are created. New jobs create a compensation for old jobs. In a certain sense the empirical literature especially in the sense of micro-economic analysis shows that there is a positive effect of product-innovation in creating job, while there is a negative effect of process-innovation in respect to employment. The positive effect of product-innovation on employment can in a certain sense compensate the negative effect of process-innovation on employment. But this "*compensation effect*" is not a natural one. It can be effectively sustained by active political economy that can finance product-innovation through Research and Development. Since Research and Development is labor friendly than the presence of political economies that can improve R&D expenditure can also increase employment. But political economies based on product innovation should also be based on educational systems that are able to improve the skills of workers.

**Innovation in high-tech and medium-tech manufacturing.**The innovation-employment nexus is positively associated to the presence of medium-tech and high-tech manufacturers. This positive relationship is due to product-innovation. In effect medium-tech and high-tech manufacturers generally prefer product-innovation to process-innovation. Product-innovation is also positively connected to exportation.Medium and high-tech manufactures are strictly oriented to exportation. But also, institutions and market structures have a relevant role in the positive relationship between innovation and employment in medium-tech and high-tech manufactures. In effect high-tech industries have generally the form of oligopoly or monopoly. These market structures can incentivize corporations to invest more in product-innovation to improve profits and preserve the market hegemony.

**Innovation in low tech manufacturing.** Innovation in low tech manufacturing has no positive relationship with employment. This lack of positive relationship is due to an orientation to process-innovation that is preferred to product-innovation and to market structures. Generally, low-tech manufactures operate in highly competitive markets. Highly competitive markets are characterized by low level of innovation andResearch and Development since firms compete on prices rather than challenge antagonists with new products and services. In this kind of markets firms have less incentives to invest in Research and Development and in job-friendly innovation. But in a certain sense also low-tech manufactures can generate employment, as it is shown in the "*compensation effect*" in figure 1. If a low-tech industry applies process innovation than it can improve productivity reducing either production costs either price of products and services. The increasing in productivity can improve the offer of products and services and by this way can augment value added in the sector. The increasing in value added generates an improve in income and wages i.e. an increase in the demand that finally promote employment. Even if the employment generated in association with process innovation is less than proportional with respect to the unemployment produced by the same process, this marginal improvement of employment can participate actively in the "*compensation effect*". Finally, even in the context of global supply chain, as shown in the literature analysis, there is the possibility even to improve routine jobs through process-innovation due to the international labour market at least until developing countries substitute workers with process-innovation. The investment in Research and Development in high-tech manufacturing also produces positive effects in the sense of corporate performance (Leogrande, et al., 2020).

**Political economies and innovation.** Since product-innovation is more oriented to generate employment while process-innovation creates unemployment it is possible to design appropriate political economies that can be useful to boost economic growth and employment together. One of the main driver to improve employment through innovation is Research and Development. Research and Development is associated to product-innovation and to improvements in employment. But to apply Research and Development investments it is necessary for the policy maker to analyze the market and distinguish among low-tech, medium-tech and high-tech manufacturers. Research and Development works moderately for medium-tech manufacturing, significantly with high -tech manufacturing, while it has no effect on low-tech manufacturing. This means that if a country, such as many European countries, has a traditional manufacture system with low or medium technology than it is highly probable that the political economies based on R&D incentives would fail to produce employment through innovation. If policy makers intend to promote employment through innovation, then they must improve the high-tech industry sector and invest in Research and Development associated to product-innovation. This kind of policies is also positive in the sense of exportations. In fact,Research and Development associated to product-innovation is positively associated not only to improving in employment but also with increasing of exportations. Finally, to improve Research and Development efficacy in high-tech industries, policy makers must also reinforce educational systems for students and for workers. The "*knowledge economy*" constitutes the main scenario for the application of the "*innovation economy*". If policy makers are able to design incentives to promote Research and Development in association with product-innovation and to create a human capital able to acquire new skills than there are rising probabilities that the investment in innovation could generate employment. Policy makers must also consider the economic determinants of innovation (Leogrande, et al., 2020).

**The institutional limitations, market competitions and innovation.** But to improve the innovation-employment nexus it is not sufficient to invest in product-innovation associated to highly-tech industries, since policy makers must also design appropriate incentive to shape market forces. For example, highly competitive markets are generally associated with process-innovation and low-tech industries with a negative impact on employment. On the other hand, medium-tech and high-tech industries are more characteristic of oligopolistic and monopolistic markets or at least markets that have reduced levels of competition. In effect firms try to reduce the pressures of competition through product-innovation based on Research and Development and by this way they can also improve employment. If policy makers want to improve employment through innovation than they should create some barriers to new incumbents in the market to preserve corporations and offer them the possibility to invest in product-innovation, improving the quality of products and services, investing in Research and Development, and promoting an orientation towards exportations. The institutional condition of markets is an essential determinant of the success of policies that try to positively active the innovation-employment nexus. If institutions can support high-tech industries than there are rising probabilities to improve employment through innovation. Finally, there are socio-economic factors that can promote the innovation-nexus in a positive way. For example countries that has a pro-scientific and pro-technological approach have greater probability to create a corporate environment that can promote highly innovative industries that invest in Research and Development, product innovation, quality of goods and services with a positive effect on employment. Policy makers have to invest either directly, through incentive to Research and Development, either indirectly, through cultural and educational policies based on the promotion of science and technology, to create the economic and productive environment able to sustain the positive manifestation of the innovation-employment nexus.

**The question of services.**The process of servitization has replaced the industrialization of the production.There are rising questions about the presence of an innovation-employment positive nexus in the service sector. The relationship between innovation and employment in the service sector is like the relationship between innovation and employment in the manufacture sector. In effect the innovation-employment nexus in the service sector:

- is positive for high-tech and medium-tech firms;
- is negative for low-tech firms;
- is positively associated to product-innovation;
- is negatively associated to process-innovation;
- shows the presence of a "*compensation effect*" if the product-innovation tends to be prevalent in respect to process-innovation.

If policy makers want to design incentives to promote the positive manifestation of the innovation-employment nexus then they should sustain medium-tech and high-tech service corporations and offer financial and fiscal support to promote Research and Development oriented to product-innovation. On the other side, if policy makers promote Research and Development in low-tech and medium-tech industries than they can waste public resources in creating unemployment through innovation. In fact, low-tech service firms are oriented to process-innovation and they can use fiscal incentives to reduce employment and to gain competitivity on the market with a reduction of costs of production and prices of goods and services. Since the great part of workforce in western and developed economies is employed in the service sector, it is clear that the investment in process innovation can create massive unemployment even in association with the increasing of profits for corporations without the possibility to activate successfully the "*compensation effect*".

**The threats of artificial intelligence.**(Ng, 2018)has defined artificial intelligence as the "*new electricity*". This can be a good definition in the sense of technological change and technological trajectories since there are many managerial and governance models that have been developed for electricity that can be used, for analogy, in the case of artificial intelligence. But on the point of view of the innovation-employment relationship the definition of Artificial Intelligence as the "*new electricity*" is bad news for workers. In fact, electricity is a process-innovation. And process-innovations are associated positively to unemployment. If Artificial Intelligence is a process-innovation than we can expect a reduction in the degree of employment associated with AI independently for the presence of high-tech industries and services. This is in effect what Artificial Intelligence promises even to high-skilled workers such as physicians, lawyers, accountants and even ICT engineers. If artificial intelligence will be considered as a process innovation by firms then managers will use it to reduce employment, cutting costs of production and reducing the price of product and services for the customers. And if politicians create political economies oriented to support artificial intelligence then they will finally incentivize unemployment even in high-skilled workers even in high-tech industries and services. But this is not a necessity. Effectively Artificial Intelligence can be considered as a product-innovation, at least in part, for the fact that it can produce new services for customers. If corporations use Artificial Intelligence, not just like electricity as suggested by the prominent scientist Ng, but also in the sense of product-innovation, then there are probabilities to improve employment trough innovation and policy makers can have an interest to incentivize AI. But the fact that Artificial Intelligence could be considered as a process-innovation or as a product-innovation is due to market forces, institutional constraints and the socio-cultural environment in which firms operate. In the absence of clear information to interpret Artificial Intelligence as a product-innovation then there are high probabilities that AI will create a massive unemployment in high-skilled workers(Schwab, 2017) with the creation of the typical effects of a process-innovation. For example Artificial Intelligence can perform efficiently administrative and managerial tasks, either in the legal department and in the accounting and finance department of firms, and can also reduce the relevance of engineers in their ability to project and implement marginal efficiency in the production process either in manufactures either in services. For example, in the medical service sector AI can substitute radiologists and other physicians obtaining more efficient results for patients. Politicians should create the cultural, institutional and market conditions that can orient corporations to use Artificial Intelligence not like the "*new electricity*" but as a tool to generate product-innovation with a positive impact on employment. If politicians will be able to design policies that can incentivize the implementation of Artificial Intelligence in the sense of product-innovation than there are rising probabilities that AI would increase employment at least in high-tech industries and services and at least for high-skill workers.

**Artificial Intelligence and the compensation effect among workers and consumers.** In the absence of political incentives, corporations can intend ArtificialIntelligence as "*new electricity"* i.e. as a new process-innovation destroying employment and impeding the activation of the compensation mechanism. But it is possible that there is the activation of a compensation effect among workers and consumers i.e. the reduction of benefits for workers can be compensated by the increase of benefits for consumers. In effect if Artificial Intelligence operates as a process-innovation, in the presence of competitive markets, then consumers can have more opportunities to buy products and services of high-tech with low prices. This in a certain sense can also have a weak effect on employment without the possibility to compensate completely the loss of jobs. Finally the benefits of the productive system with Artificial Intelligence will be translated from workers to consumers, creating new typologies of consumers, that are the prosumers i.e. consumers that in the act of consumption are also engaged in some form of production based on knowledge and quasi-professional skills. This scenario will not be able to sustain a large workforce and seems to be more associated to massive unemployment. And it is for these arguments that the anthropologist and political scientists have forecasted the necessity of a universal income to sustain the useless class (Harari, 2017)i.e. the large part of population that will not be employed in the productive system based on Artificial Intelligence.

The sequent parts are as follow: the second paragraph critically discusses the literature on the difference of product-innovation and process-innovation in connection with employment; the third paragraph presents the estimated model; the fourth paragraph concludes. The appendix shows the econometric results and tables of data with graphical representations.

## II. LITERATURE REVIEW

(Bianchini & Pellegrino, 2019)afford the question of the relationship between the level of innovation and the dynamic of employment in Spanish manufacturing firms. The authors create a connection among the creation of innovation, the process of innovation persistence and different trajectories in the growth of employment.The authors find that firms that perform a model of persistent innovation can have greater impact in terms of employment. For each level of innovation, it is possible to build a correspondent level of employment in manufacturing firms. There is a difference between product-innovation and process-innovation in the sense of employment. While on one side product-innovation is associated positively to the increase in employment, on the other side process-innovation does not have any significant role in boosting employment. The dominance of product-innovation in respect to process-innovation in the sense of employment is particularly relevant for SMEs. The degree of employment that is associated positively with the development of product-innovation is significantly higher in the contest of small and medium enterprises. The authors conclude their article suggesting that product-innovation has a relevant impact to promote employment. One of the main points of the article is based on the idea of the juxtaposition between product and process innovation. Product and process innovation have different impacts in terms of employment. The authors find the presence of a path-dependence for highly innovative firm in the sense that a firm that innovate in a certain period has a high probability to innovate also in the next period. There is a sort of persistence in the process of continuous innovation. The ability of a firm to be continuously successful in the process of innovation can be motivated with the presence of sunk costs and increasing returns. Firms that invest continuously in innovation can afford better the presence of shadow costs that can impede the implementation of Research and Development. Firms can be classified in respect of their ability to perform innovation in two different groups in respect to the frequency of innovation: on the one side we have firms that innovate continuously since Research and Development constitute a fixed cost in their production function, while on the other side there are firms that innovate only partially or discontinuously since their core business is not effectively oriented to the promotion of innovation, neither in the sense of product-innovation neither in the sense of process-innovation.

**Innovation, evolution, and employment**. (Audretsch & Roy T., 1999)analyze the relationshipsamong innovation, evolution, and employment. The article affords the question of the relationship between rising unemployment in Europe and the application of political economies that boost innovation. Authors affirm that policies have been considered as a choice between two different stage: on the one side low unemployment obtained by paying low wages to workers, and on the other side high unemployment compensated with high wages for workers. The authors consider that while Anglo-American policies have chosen to reduce the level of wages to improve the level of general employment, the opposite choice has been performed in Europe, where policy makers have increased the level of wages and have tolerated a higher degree of unemployment. But in the ideas of the authors there is a third alternative to this dichotomy i.e. to embrace a structural change that can be realized through a shift from traditional moderate-technology industries to new emerging tech-intensive industries. Innovation can solve the question of the negative trade-off between employment and the level of wages.

**The zero-sum game between innovation and employment**. (Vivarelli, 2007)affords the question of the zero-sum game between the development of technology and the negative impact on employment. The author sustains that the fear of technological innovation has been a characteristic of every industrial revolution. There are deep traces of these phenomena such as for example the diffusion of luddism during the first industrial revolution. But the hypothesis of the presence of a zero-sum game between innovation and employment has been challenged in the same economic theory. In this sense the author cites David Ricardo and his political view of the question. Ricardo was persuaded that while on the one side working class considers the existence of a negative sum game between innovation and employment, on the other side the academic and political elite was more persuaded of the presence of market forces able to compensate the "*dismissed workers*". The author suggests to analyze long term technological trajectories to understand the relationship between innovation and unemployment. The orientation to shortermist choices purely based on the gain in profits based on technological innovations are not able to give the exact impact that new paths of knowledge have on employment. The author presents the idea of "*compensation theory*" that statues that every change in innovation and technology is effectively neutral in the sense of labor since it create new jobs that compensate workers from having lost the previous one. But even if there are surely the presence of a positive effect in the sense of compensation this force is less than proportional. The number of new jobs that are associated to new technologies is lower than the number of old jobs that have been destroyed by the introduction of innovations. But the author suggests the peril that the relationship between innovation and employment could become effectively a new ideological debate without empirical analysis. In any case there are contrasting econometric results about the presence of a zero-sum game between innovation and employment. In effect even if at a micro-level there are confirmations of the presence of a positive relationship between innovation and employment, these results cannot be effectively generalized. The author suggests to better investigate the topic distinguishing between product-innovation and process-innovation. The author expresses skepticism about the possibility to find a unique solution to the question of the relationship between innovation and employment. But critically, we have to say that the introduction of Artificial Intelligence and machine learning has created the premise for massive unemployment. Even if these innovations promise to increase GDP per capita and productivity they certainly are oriented to create large unemployment especially in white collar professions such as journalists, lawyers, accountants and even physicians. These negative effects of Artificial Intelligence and machine learning on employment will be less than compensate by the creation of new jobs based on the new disruptive technology.

**The supposed positive effect between innovation and employment**. (Piva & Vivarelli, 2005) afford the question of the supposed presence of a positive relationship between innovation and employment. The main hypothesis is that technological change has a positive effect on jobs, at least at a firm level. The authors investigate the role of intermediate technologies in respect to employment using data from 575 Italian firms in the period 1992-1997. The authors effectively find a positive confirmation of their hypothesis, even if the effect is small. The authors suggest the presence of a long controversy between innovation and employment. The compensation theory sustains that the number of jobs created by new technologies can compensate the loss of jobs due to the same new technologies. The analysis of the impact of innovation in industry and manufactures shows that there are two different kinds of technological impacts on employment:

- Process-innovation is labor-saving i.e. the degree of employment declines with the increase in technological changes;
- Product-innovation is labor-intensive i.e. employment improveswith the increase in technological changes.

But the net effect of these two elements is not perfectly clear. There are income and price mechanisms that operate at a firm level, ad a sectorial level and even at an inter-sectorial level. The authors suggest that technological change can reduce prices and increase incomes crating the premise for a boost in employment. The counterbalancing effect of the labor intensity in product-innovation should compensate or at least less than compensate the labor-saving effect of process-innovation. But controlling for the level of the firm the authors find a positive relationship between innovation and employment. The micro-economic approach of the authors, even if it is based on rigorous econometric analysis cannot be generalized. In effect there are macro-economic effects that cannot be captured in a micro-economic analysis. The presence of a positive relationship between innovation and employment is essentially due to the presence of product-innovations that operate at a firm level in the analyzed data.

**The political economics of innovation-employment conciliation**. (Vivarelli, 2014) affords the role of political economics in their effort to conciliate technological innovation and employment. The author suggests that the development of a system based on technological innovation does not produce per sè neither employment neither economic equality. But effectively some technological changes and trajectories are clearly able to reduce employment and boost economic inequality. This is the case of Artificial Intelligence, machine learning and big data. But the author is not pessimistic about the necessity of a negative relationship between innovation and employment since policy makers can intervene in reducing the negative impact of labor-saving innovation and improving the effect of labor-intensiveinnovations. If political economies are oriented to boostlabor-intensive innovations than also economic equality can be better pursued. The author suggeststo invest more in education to improve the skills of employment and reduce the skill-biased technological change. Policy makers can choose to finance product-based innovations that are more connected to Research and Development and by this way increasing employment.

(Vivarelli, 2007) affords the question of the relationship between technological change and employment. The introduction of technological change reduces employment in many developed countries. The author suggests that product-innovation creates new jobs, new firms, and new markets, while process-innovation can effectively destroy jobs. But even process-innovation can have a positive effect on jobs if there are appropriate market forces and mechanisms that can compensate the job-destruction with a job-creation. Policy makers can effectively reduce the negative impact of process-innovation on job markets and improve the positive impact of product-innovation in creating new opportunities for workers. The author considers the essential role of Research and Development that is associated to product-innovation and by this way to greater job creation in confrontation to process-innovation. Policy makers in this sense can improve incentive to Research and Development and by this way they can improve either innovation either employment. But it is not always possible to distinguish process-innovation and product-innovation since the two elements are sometimes intertwined in complex systems. Even if a sort of compensation mechanism does exist in association to innovation it cannot be assumed ex ante. To create a compensation effect, it is necessary to reduce monopolistic rents and this require in a certain degree the intervention of policy makers. The theoretical question about the existence and the dominance of the compensation effect cannot be solved. Only econometric analysis can indicate if there exist a hegemony of the compensation effect in respect to product-innovation on process-innovation. The author finds that the econometric analysis shows the positive role of Research and Development in generating employment and innovation especially boosting product-innovation. Policy makers can improve the incentives in Research and Development to create the condition to produce innovation associated to employment.

(Van Roy, et al., 2015) afford the presence of a positive relationship between innovation and employment. The authors analyze a panel data based on 20.000 patenting firms in Europe in the period 2003-2012. The authors find that innovation is labour friendly. But this positive relationship between innovation and employment works only for high tech manufacturing firms. The same relationship is not significant for low-tech manufacturing firms. The authors consider positively the role of ICT in creating new jobs even considering its disruptive effect in terms of old jobs and skills. The authors consider the fact that product-innovation creates new jobs while process-innovation destroys jobs. The effect of job creation in product-innovation should counterbalance the effect of process-innovation. But innovative firms have also a positive impact for the economy since they can share part of their extraprofits in the form of wages. The additional incomes can promote new jobs, improving demand and augmenting consumption. But these compensation mechanisms can be abrupted in the case of monopoly. The authors consider the possibility of the presence of a positive relationship between innovation and employment. The economic literature has shown the presence either of product-innovation with its labour-friendly consequences either of process-innovation with its labour-saving effect. But theoretically it is not possible to determine what of the two effects is dominant in respect to the other.

(Piva & Vivarelli, 2018) afford the question of the relationship between innovation and employmenteither theoretically either empirically. The authors found two main results:

- *There is a significant positive effect of Research and Development expenditures in the sense of innovation:* this positive effect is due to investment in Research and Development that is realized in high-tech sectors, while there is not positive effect in Research and Development expenditure in respect to low-tech firms;
- *Capital formation is labor-saving*: the investments that firms realize in acquiring new stocks of capital are negatively associated to employment. This negative effect is due to the positive association between capital formation and process-innovation.

The authors suggest that the relationship between innovation and employment is characterized by the presence of complexity. In effect technological change has either direct effect indirect effects in the sense of employment. This complexity is due to the controversial relationship between product-innovation that can improve jobs, and process-innovation that is associated to job destruction. But also process-innovation has some positive externalities. Process-innovation can reduce prices and can increase income and by this way can boost demand and production partially compensating the initial loss of jobs. These effects depend also on institutional and policy constraints and incentives. The relationship between the potential labor-saving effects of process innovation and the labor-intensive effects of product innovation is due to socio-economic, cultural, and political variables. But the positive relationship between product-innovation and employment can be verified only in high-tech manufacturing. In this sense policy makers can improve the investment in Research and Development since R&D is strictly connected with product-innovation. The possibility to develop a positive relationship between innovation and employment depends also on policy makers that can choose the degree of incentives that can be invested in politics that boost knowledge and human capital. But to be effective the investment should be realized in high-tech industries and in this sense policy makers should promote greater aggregation among corporations to create industrial sectors able to sustain the R&D processes.

(Piva & Vivarelli, 2018) analyze the relationship between technology and employment in the consideration of the impact of differentiated technological trajectories for qualifications and tasks. The authors consider the impact of new technologies in the process of creating new jobs. But the pression that technology has on jobs is a

not an exclusive characteristic of developed country it is also a question for developing countries. The diffusion of Artificial Intelligence and machine learning has created a new sense of fear for the unemployment that technology seems to generate. Artificial Intelligence is a threat for workers in service sectors including also cognitive professions such as lawyers, physiciansand scientists, musicians and painters. If automation has destroyed jobs in the manufacturing sector, then Artificial Intelligence is oriented to reduce employment in the service sector. The authors introduce the idea of the compensation effect i.e. the presence of a challenge between the reduction of labour force connected to process-innovation and the creation of new jobs in association with product-innovation. But the net effect is not clear neither in the economic literature neither in empirical data. In fact, even if econometric analysis shows that there is a positive relationship between Research and Development and employment through product-innovation, on the other side there is also some weak positive effect on employment that also process-innovation can produce in the economic system by lowering prices and increasing demand. While the existence of a compensation theory is certainly a fact, there are ambiguities on the fact that the number of job created in connection of the mix of product and process-innovation can be structurally grater that the number of jobs destroyed by the same technological change.
The ability of product-innovation to create jobs seems to be dominant in respect to the reduction of jobs due to process-innovation. A relevant role is played by the type of manufacturing considered. High tech-manufacturing is associated to grater job creation in respect to low-tech manufacturing. To create new jobs in connection with innovation is necessary to invest in human capital. Technology requires new skills and new abilities. Policy makers can intervene improving the quality of educational systems not only for students but also for workers. In particular new technologies, such as Artificial Intelligence and machine learning, can destroy routine jobs even in the service sector. The authors do not have a final solution for the dilemma between the prevalence of compensation theory or the prevalence of technological unemployment. Since corporations are investing in boosting Artificial Intelligence and machine learning to substitute white collars jobs then policy makers should try to create incentive to defend either low-skilled workers either jobs in the service sector that are highly routinized. To solve the question the authors, suggest to investin Research and Development. In fact, Research and development can boost product innovation that is positively associated to employment.
(Bogliacino, et al., 2012) show the existence of a positive relationship between Research and Development and employment. The authors find that this relationship is statistically significant even if it has a small magnitude.The positive association between Research and Development and employment is considered as a consequence of the presence of product-innovation. In effect Research and Development is strictly connected to product-innovation, and product-innovation is positively associated to employment.

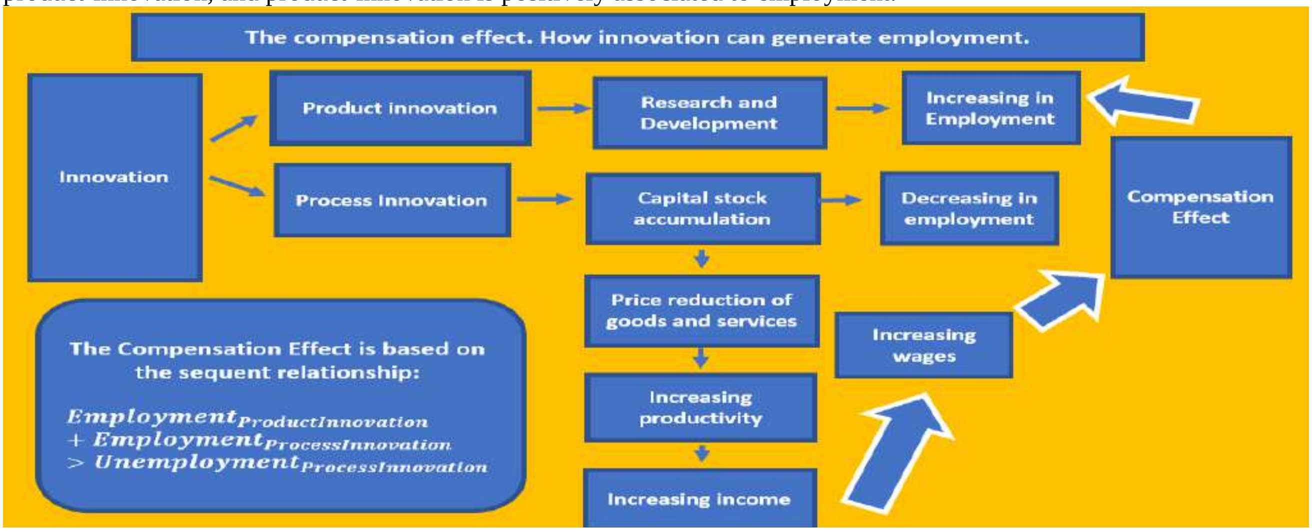


*Figure 1. The compensation effect is due to the increasing in employment generated by product-innovation plus the increasing in employment due to process innovation. This summation should be greater than the level of unemployment generated byu process-innovation. Or in other form:* $\boldsymbol{Employment_{ProductInnovation}} + \boldsymbol{Employment_{ProcessInnovation}} > Unemployment_{ProcessInnovation}$

But the increasing level of employment due to Research and Development in product -innovation does not works for every industrial sectors. It works only for high-tech manufactures. So, the condition to have a positive impact of innovation on employment is based on the sequent system:

$$\begin{cases} \boldsymbol{Employment_{ProductInnovation}} + \boldsymbol{Employment_{ProcessInnovation}} > \boldsymbol{Unemployment_{ProcessInnovation}} \\ \dfrac{\Delta ValueAdded_{highTechManufacturing}}{\Delta ValueAdded_{Manufacturing}} > 1 \end{cases}$$

This means that the analysis of compensation effect cannot be considered without controlling for the ability of the manufacturing systems to be oriented to high-tech products and processes. Or in other words, if a country has low-tech manufacturing and invest in Research and Development, the compensation effect could not be active, and the level of employment could be reduced. For this reason, it is not sufficient that policy makers incentivize Research and Development, even in the sense of product-innovation. To have a good impact on employment, policy makers should promote Research and Development in high-tech manufacturing. In this case there are positive effects on employment. Also the article of(Piva & Vivarelli, 2018) shows the presence of a positive relationship between Research and Development expenditures and employment for European firms. But this positive relationship works only if Research and Development is associated to medium and high-tech manufacturing. The suggestion for policy makers is not to invest generically in Research and Development. At the contrary, the suggestion for politicians is to associate the level of investment in Research and Development to high-tech manufacturing or at least medium-tech manufacturing, avoiding the investment in low-tech manufacturing. The authors investigate the presence of institutional and market limitations that can reduce the efficiency of political economies oriented to improve employment through Research and Development. For example, the presence of imperfect competition, negative expectations, or other limitations due to socio-economic context can vanish the level of R&D ability to generate employment. But we must criticize this point for the fact that generally high-tech industries do not operate in perfect competition. In effect high-tech industries are generally associated to monopoly or oligopoly such as in the case of automobile industry, or even the case of big tech industries. So, there is a contradiction between affirming that Research and Development can create employment in high-tech industries and putting the limitation of imperfect market mechanism. This is due to the fact that the incentive to invest in high-tech industry can be sustained only in markets that are more oriented to a model similar to "*the winner takes all*" that are in general the form of monopoly or oligopoly. In effect entrepreneurs, small firms and corporations that operate in extremely competitive markets generally do not have incentive to invest in innovation and specifically they never invest in Research and Development.

(Van Roy, et al., 2018) affords the question of the relationship between the job creation and the innovation activity. The authors find a positive association between the investment in innovation and the level of employment. The authors confirm the presence of a positive relationship between innovation and employment in high-tech and medium-tech industries. The same relationship is absent in low-tech industries. The authors suggest to policy makers to create incentives to improve product-innovation in high-tech and medium-tech manufacturing to have a positive effect on employment. The quality of innovation is positively associated to employment, and policy makers can improve employment by increasing the quality of innovation. Traditional firms, for example in agriculture, construction, and manufacture of goods, generally do not implement innovation and quality and for these sectors there are low probabilities to improve employment through innovation.

(Vivarelli, et al., 1996) afford the question of the relationship between innovation and employment in Italian manufacturing. The authors investigate the role of technological change, the difference between product-innovation and process-innovation and the role of embodied and disembodied technical change. The authors find a specificity of Italian economy among developed countries in its ability to integrate technological change, value added, employment and investment. The Italian economy shows a negative relationship between employment growth and productivity. The authors find that the investment in innovation, especially through an increase in fixed capital is associated to a decrease in employment in the case of Italian economy. This mese that, at least for the Italian case, there is an inverse relationship between technological innovation and employment. Specifically, the presence of a negative relationship between technological innovation and employment in the case of Italian economy is due to the prevalence of process-innovation on product-innovation, a condition that impede the application of the compensation effect. To solve the question the authors, suggest increasing the investment in product-innovation. The Italian economy is characterized by the presence of a negative relationship between innovation and employment, and the increase in productivity is essentially associated to an increase in unemployment. In the analysis of the authors the "*compensation effect*" seems to be deactivated for the Italian economy. But this negative relationship is essentially due to the presence of investments in capital stock and process-innovation. The positive relationship between innovation and employment can be restored if Italian firms substitute process-innovation i.e. based on capital accumulation to product-innovation that is based on Research and Development. In effect both innovation increase productivity. But while, on one hand process-innovation increase productivity whit a negative impact on employmenton the other hand the investment in product-innovation can boost productivity with a positive impact on employment essentially based on Research and Development.

**Innovation and employment.**(Marcolin, et al., 2016) affords the multiple relationship among workforce, ICT, innovation, industrial structure, and employment in the global value chains. The authors consider the role of global value chains and their impacts on routine and non-routine occupations. Higher skills are associated to higher employment non routine jobs, while low skills are connected to routine jobs. The authors find that controlling for patents, there is a positive relationship between innovation and employment in general with no distinctions between routine and non-routine jobs. Due to the complexity of the global value chain it is not possible to identify specifically winners and losers in the distribution of jobs among countries. And authors find a positive relationship between innovation and employment and, paradoxically, they find a positive relationship even between innovation and high routine occupations. This result can be considered as controversial. But effectively low-income countries that participate in global value chain tend to improve the degree of high routine jobs while developed countries are characterized by an increase in non-routine jobs.Authors suggest that even this distribution of opportunities among countries could be challenged by technological change and even non-routine jobs in poor country could disappear due to innovation. But even considering the impact of this disruptive innovation the authors find a positive relationship between innovation and job creation in routine-occupations.

(Addison & Teixeira, 2001) analyze the relationships among technological change, the structure of relative employment and wages. The authors consider that technological change requires an increase in skills for workers. And this means that the possibility to improve employment is strictly connected to the educational system. Better educated workers have higher probability to survive to technological change. The skill-bias can create discrimination in the workforce. To solve the question, the authors suggest to politicians to improve the educational system to give more opportunities to workers that have low skills and training and that due to this condition can suffer for unemployment.

(Antonucci & Pianta, 2002) affords the question of the relationship between innovation and employmentconsidering either the interaction between demand andlabour costs either the variety of patterns in technological change. The authors consider three different scenarios:

- Firms try to compete in quality through product-innovation with a positive impact on employment;
- Firms try to compete in reduction in prices and invest in process-innovation with a negative impact on employment;
- Non-innovators try to reduce costs and prices through imitative behaviors.

The authors considering the European economy conclude that there is a negative relationship between innovation and employment. This negative innovation is due to the dominance of process-innovation on product-innovation in European countries.

(Brouwer, et al., 1993)analyze the role of innovation on employment in Dutch manufacturing. The authors find the sequent results:

1. Firms with a high share of product related to R&D have a positive impact on employment;
2. The increasing in R&D intensity is associated to a decline in employment;
3. Small firms that invest in R&D related to ICT have a positive effect on employment;
4. Large firms that invest in R&D in the sense of ICT have a negative impact on employment;
5. Cooperation in R&D has no impact on employment.

The propositions 1 and 2 seems to be in juxtaposition but they are not opposed since R&D is able to generate employment only in connection with high-tech and medium-tech manufacturing while in the case of low-tech manufacturing there is no positive effect of R&D on employment. In adjunct it is necessary to consider that R&D investments associated to process-innovation is not able to generate an increase in employment. The third proposition can be explained considering that small firms that implement R&D in ICT can improve their efficiency and their productivity and by this way can improve employment. The fourth proposition can be associated to the presence of process-innovation: large firms can have greater incentives to substitute processes with ICT reducing employment. The fifth proposition can be understood considering that R&D can have a positive effect on employment essentially through product-innovation and generally if firms have to develop new products tend to reduce their cooperative behavior to preserve their ideas and projects.

(Dobbs, et al., 1987) afford the question of the relationship between technological change and unemployment. The authors synthetically afford three questions:

- The role of technical change at the firm level and its industry-dependence;
- The impact of changes on the whole industry with the mechanisms of entry and exit of corporations;
- The impact of innovation on general equilibrium.

The main point of the authors is the fact that the innovation-employment nexus changes with industry. The reaction of a certain industry to the innovation-employment nexus depends on many variables such as demand elasticities and elasticities of substitution. But there are also other important factors such as for example: firm numbers and economies of scale. Elasticity of substitution has a great role for the innovation-employment nexus. If elasticity of substitution increases than firms can improve capital in the reduction of employment. On the other side if a firm operate in an international competition has a more elastic demand for its product and this means that the increasing in innovation also generates an augmenting in employment. The authors suggest that high-tech industries have the characteristics to improve employment through innovation.

(Evangelista & Savona, 2002) afford the question of innovation and employment in service sector in the Italian economy. Data shows that there is a great variance in the response of sectorial innovation to employment that depends also from the qualifications and skills of workers. The authors find a positive relationship between innovation and employment in service sector especially in high-tech services. In other sectors, such as banking and financial services, there is a negative relationship between innovation and employment. Controlling for the entire service sector in Italy the authors find a negative relationship between innovation and employment. The authors conclude that this negative relationship is due to the fact thatItalian firms are more active in traditional services rather than science-oriented services.

**Innovation and exportation.**(Becker & Egger, 2013) afford the question of the relation of product-innovation and process-innovation in respect to the ability of the firm to export. Product-innovation is the main driver to improve exportation and it is also positively correlated to increasing in employment through Research and Development. Process-innovation increases the ability of a firm to compete in efficiency through a reduction in prices and an optimization of the production function. Also process-innovation is expected to be positively related to an increase in exportation. But the authors assume that product-innovation ability to promote exportation is greater in respect of that of process-innovation. The analysis of the authors reinforces the idea that product-innovation should be preferred to process-innovation not only for its ability to be strictly connected to employment, especially in medium and high-tech industry, but also because it consents also to improve exports.

## III. THE MODEL

We have estimated the sequent model:

$$\begin{aligned}\boldsymbol{EmploymentImpacts_{it}} &= \boldsymbol{a_1} + \boldsymbol{b_1}(\boldsymbol{AverageAnnualPopulationGrowth})_{it} \\ &+ \boldsymbol{b_2}(\boldsymbol{BasicScholEntrepreneurailaEducationAndTraining})_{it} \\ &+ \boldsymbol{b_3}(\boldsymbol{BuyerSophistication})_{it} + \boldsymbol{b_4}(\boldsymbol{EaseOfStartingABusiness})_{it} \\ &+ \boldsymbol{b_5}(\boldsymbol{FirmInvestments})_{it} \\ &+ \boldsymbol{b_6}(\boldsymbol{ForeingControlledEnterprisesShareOfValueAdded})_{it} \\ &+ \boldsymbol{b_7}(\boldsymbol{GovernmentProcurementEnterprisesShareOfValueAdded})_{it} \\ &+ \boldsymbol{b_8}(\boldsymbol{HumanResources})_{it} + \boldsymbol{b_9}(\boldsymbol{Linkages})_{it} + \boldsymbol{b_{10}}(\boldsymbol{SalesImpacts})_{it}\end{aligned}$$

We perform an analysis with WLS, panel data with fixed effects and random effects. We use data from European Innovation Scoreboard that analyze data from 36 countries in the period 2000-2019.

**Independent variable**. We estimate the employment impact on innovation. Specifically, the exact definition of employment impact is as follows:

> «*Employment impacts measures the impact of innovation on employment and includes two indicators measuring Employment in knowledge-intensive activities and Employment in fast-growing firms in innovative sectors.*»(Commission, 2019)

We cannot explicitly distinguish in this case between employment due to product-innovation and employment due to process-innovation. The independent variable "*Employment Impacts*" sum up the two different typologies of innovation.

**Dependent variables.**We find that the independent variable "*Employment Impacts*" is associated:

1. *Positively with "Annual population growth":*the positive relationship between annual population growth and the positive effect on employment in the innovation sector must be considered with referring to the specific database. In effect, in Europe, the most populous countries are also the most innovative ones. Germany, France, and UK are among the most innovative countries in the world economy and they are also very populous countries with rising demographic trends. But this relationship can be also interpreted as an overcoming of the idea of "*demographic transition*" that is the proposition for which the rising level of Gdp per capita, that is also generally an increase in employment, is also accompanied with a decline in demographic trends.Most innovative countries show the ability to a twofold growth in demographic trends and employment.
2. *Positively with "Basic-school entrepreneurial education and training":*the education training in entrepreneurship is a good proxy for the improvement of employment in innovative sector. In effect also in the analysis of the literature we have found the presence of a positive relationship between educational system and the positive manifestation of the innovation-employment nexus. Policy makers that are interested in boosting positively innovation and employment can invest in entrepreneurial education and training. The human capital has a positive impact on innovation in the knowledge economy. In particular increasing the level of human capital can improve not only the percentage of high-skilled workers able to create innovative firms but also can increase the orientation to high-tech manufactures that are associated to product-innovation and to the higher employment rate;
3. *Negatively with "Buyer sophistication":* the buyer sophistication is defined as the ability of the buyer to prefer quality over price. The negative relationship between employment in innovation and buyer

sophistication means that the employment in innovation in Europe tends to be more oriented to process-innovation that to product-innovation. In effect sophisticated buyers tend to acquire product at a higher price that are associated to product-innovation. On the other side the presence of process-innovation can reduce the price of products and services and by this way tend to be preferred from non-sophisticated buyers. This result is coherent with the literature analysis in the paragraph 2 that has showed that while, on one side, product-innovation is oriented to improve the quality of products and services, on the other side process-innovation reduces the prices of goods and services.

4. *Positively with "Ease of starting a business":*there is a positive relationship between the ease of starting a business and the employment associated to innovation. This can suggest the presence of a positive relationship between the efficiency of the administrative system and the ability of firms to produce innovation and employment. The facility to starting a business can be considered as an incentive for entrepreneurs to invest more and to produce innovation and employment. The presence of a positive administrative environment can improve startups, innovative firms, with a positive effect on employment.
5. *Positively with "Firm investment":*the level of investment in innovation is positively associated to employment in Europe. This result offers a suggestion for the presence of a compensation effect between the number of jobs that have been destroyed and the number of jobs that are created with innovation.
6. *Positively with "Foreign controlling enterprises":* the European Innovation Scoreboard-Methodology Report (Commission, 2019)defines *"Foreign controlling enterprises"* as«*Value added by foreign-controlled enterprises at factor cost in million euros for non-financialbusiness economy. A foreign-controlled enterprise shall mean that the controllinginstitutional unit is resident in a different country from the one where the institutional unitover which it has control is resident.»*The presence of a positive relationship between "*Foreign controlling enterprises*" and "*Employment Impacts*" shows the presence of an international innovation system that is able to produce value added also with the off-shoring of technological and scientific services.
7. *Positively with "Government procurement and advanced technology products":*this means that if a government increases its investment in innovation than also the level of employment associated to innovation sector growths. This is a measure of the efficacy and efficiency of governmental policies in promoting the positive nexus between innovation and employment.
8. *Positively with "Human resources":*the level of human resources is essential to promote Research and Development that is positively associated to employment through product-innovation. The countries that have human resources(Leogrande, et al., 2020)with high skills can improve the medium-tech and high-tech industries and services with a positive effect in the sense of innovation. Policy makers that are interested in increasing employment in innovative sector must also improve the education system to improve the level of technical skills, abilities, and knowledge in the workforce.
9. *Negatively with "Linkages":*in the analyzed dataset linkages are considered as the degree of collaborations either among innovative firms either in private either in public sector. This collaboration does not produce employment. The motivation can be found in the fact that, as discussed in paragraph 2, only product-innovation is able to produce employment. But if a firm or a corporation intend to invest in a product-innovation tends to protect it and has no interest in collaborating with other firms or even with the public sector.This means that firms tend to share only projects that have a low efficiency in the sense or innovation, or that are more oriented to process-innovation.
10. *Positively with "Sales impact":*sales impact as indicated in the European Innovation Scoreboard (Commission, 2019)measures « *[...]economic impact of innovation and includes three indicators measuring Exports of medium and high-tech products, Exports of knowledge-intensive services, and Sales due to innovation activities*». The existence of a negative relationship between the employment produced by innovation and the level of sales impact shows that the degree of innovation in European countries can be considered as a proxy of process-innovation rather than a proxy of product-innovation. In fact, as shown in the literature analysis of paragraph 2, the possibility to improve exportations is strictly connected with the presence of product-innovation. The main suggestion in this case for policy makers consists in the creation of incentives that can boost medium and high-tech industries and services that are able to perform product-innovation.

Our analysis shows that the employment related to innovation is positively associated to business and entrepreneurship activities, positive demographic trends, and performance and structure of the economy. "*Buyer sophistication*" and "*Linkages*" are both associated to a reduction in "*Employment Impact*" showing that the innovation sector in Europe must create more quality in products and less process-innovation. Specifically if policy makers want to promote a positive innovation-employment nexus they also should improve the attractiveness of European research system to improve the orientation towards high-tech manufactures and industries(Leogrande, et al., 2020).

| The estimation of employment impact in innovative sectors. Source: European Commission | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | WLS | | Fixed Effects | | Random Effects | |
| Abbreviation | Variable | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value |
| | *const* | 19,0103 | *** | 59,4123 | *** | 59,4287 | |
| A3 | *Average annual population growth (SD)* | 15,0707 | *** | 7,91479 | *** | 7,91128 | *** |
| A4 | *Basic-school entrepreneurial education and training (SD)* | 0,131001 | *** | 0,2261 | *** | 0,225677 | *** |
| A6 | *Buyer sophistication (SD)* | -22,3774 | *** | -12,3058 | *** | -12,2974 | *** |
| A8 | *Ease of starting a business (SD)* | 0,977797 | *** | 0,40695 | ** | 0,406816 | ** |
| A18 | *Firm investments* | 0,207463 | *** | 0,25184 | *** | 0,25178 | *** |
| A20 | *Foreign-controlled enterprises – share of* | 0,773447 | *** | 0,90378 | *** | 0,902662 | *** |
| A22 | *Government procurement of advanced technology products (SD)* | 0,38792 | *** | 0,36818 | *** | 0,368577 | *** |
| A23 | *Human resources* | 0,233258 | *** | 0,46673 | *** | 0,465656 | *** |
| A33 | *Linkages* | -0,33075 | *** | -0,32216 | *** | -0,32262 | *** |
| A49 | *Sales impacts* | 0,953029 | *** | 0,63256 | *** | 0,634946 | *** |

*Figure 2. A synthesis of the main results of the regression analysis for the estimation of the employment impact of innovative sectors.*

## IV. CONCLUSION

Our analysis investigates the determinants of the innovation-employment nexus in 36 European countries in the period 2000-2019. Data are collected from the European Innovation Scoreboard 2019 of the European Commission. We found that We find that the level of employment for innovative firms is positively associated with "*Average annual population growth*", "*Basic-school entrepreneurial education and training*", "*Ease of starting a business*", "*Firm investments*"; "*Foreign controlled enterprises-share of value added",* "*Government procurement of advanced technology products*", "*Human resources",* "*Sales impacts*" and negatively associated with "*Buyer sophistication (SD)*", "*Linkages*".

The literature analysis shows that there are significantly differences between process-innovation and product-innovation in the sense of employment. In effect while product-innovation is positively associated to employment, process-innovation is positively associated to unemployment. The economic theory as supposed the existence of a "*compensation effects*" i.e. the ability of an innovation to produce more jobs than the jobs destroyed. The existence of the "*compensation effects*" can be verified under particularly constraint that can be synthetized in the sequent formula:

$$\boldsymbol{CompensationEffect \rightarrow Employment_{ProductInnovation} + Employment_{ProcessInnovation} > Unemployment_{ProcessInnovation}}$$

This formula is based on the idea that the employment impact of process-innovation can be divided in two parts: one that is positively associated to employment and one that is negatively associated to employment. Generally, the negative element prevails on the positive i.e. the relationship between the job destroyed and the job created is more than proportional in the case of process-innovation. But since product-innovation and process-innovation are in many cases intertwined then it can be useful to verify if the sum of job creation of product-innovation and process-innovation is greater than the job-destruction of process innovation. If this condition is matched than the manifestation of the "*compensation effect*" is verified.

But the positive innovation-employment nexus can be verified only in medium-tech and high-tech manufactures and services. For low-tech manufactures and services also the investment in Research and Development does not produce a positive impact in the sense of employment. This means that policy makers must create incentives for Research and Development able to boost product-innovation in medium and high-tech industries to have the effect of creating employment through innovation. In other case also incentive to Research and Development could fail to produce a result in terms of employment.

The question of the relationship between innovation and employment is relevant for the service sector especially in connection with Artificial Intelligence. Artificial Intelligence has been described by Ng as the "*new-electricity*". If this is true than we can expect a massive reduction in employment due to Artificial Intelligence since electricity is more closed to a process-innovation rather than to a product-innovation. But this is not necessarily a destiny for the productivity of high-tech industry and for high-skilled workers since political economies can have the ability to drive Artificial Intelligence towards more product-innovations saving jobs.

Since innovation is one of the main drivers of economic growth it is necessary for governments to find solutions that are also able to preserve employment. The economic theory suggests that product-innovation in high-tech industry and service can be considered as a driver not only for economic growth but also for employment. Our analysis in part confirm this main orientation and goes beyond in recognizing especially the role of a country to promote business and entrepreneurship activities and the general performance and structure of the economy as a tool to improve the innovation-employment nexus.

But European countries are not sufficiently oriented to high-tech industries and services and must invest more in high-tech manufactures to improve employment through innovation. In this sense policy makers can introduce incentives to improve product-innovation andhigh-tech industries and servicesEurope.

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## 6. Appendix

$$\begin{aligned}\boldsymbol{EmploymentImpacts_{it}} &= \boldsymbol{a_1 + b_1(AverageAnnualPopulationGrowth)_{it}} \\ &+ \boldsymbol{b_2(BasicScholEntrepreneurailaEducationAndTraining)_{it}} \\ &+ \boldsymbol{b_3(BuyerSophistication)_{it} + b_4(EaseOfStartingABusiness)_{it}} \\ &+ \boldsymbol{b_5(FirmInvestments)_{it}} \\ &+ \boldsymbol{b_6(ForeingControlledEnterprisesShareOfValueAdded)_{it}} \\ &+ \boldsymbol{b_7(GovernmentProcurementEnterprisesShareOfValueAdded)_{it}} \\ &+ \boldsymbol{b_8(HumanResources)_{it} + b_9(Linkages)_{it} + b_{10}(SalesImpacts)_{it}}\end{aligned}$$

| *WLS, using 360 observations* | | | | |
|---|---|---|---|---|
| *36 cross section unities are included* | | | | |
| *Dependent Variable: Employment Impacts* | | | | |
| *Weights based on variances of errors per unit* | | | | |
| | *Coefficient* | *Std. Error.* | *t-statistics* | *p-value* |
| *const* | 19,0103 | 3,01272 | 6,310 | <0,0001 *** |
| *A3* | 15,0707 | 5,19354 | 2,902 | 0,0039 *** |
| *A4* | 0,131001 | 0,0472740 | 2,771 | 0,0059 *** |
| *A6* | -22,3774 | 7,70414 | -2,905 | 0,0039 *** |
| *A8* | 0,977797 | 0,370711 | 2,638 | 0,0087 *** |
| *A18* | 0,207463 | 0,0510748 | 4,062 | <0,0001 *** |
| *A20* | 0,773447 | 0,190303 | 4,064 | <0,0001 *** |
| *A22* | 0,387920 | 0,0776530 | 4,996 | <0,0001 *** |
| *A23* | 0,233258 | 0,0670975 | 3,476 | 0,0006 *** |
| *A33* | -0,330750 | 0,0769282 | -4,299 | <0,0001 *** |
| *A49* | 0,953029 | 0,0879863 | 10,83 | <0,0001 *** |
| **Statistics based on weighted data** | | | | |
| *Residual sum of squares* | 66,49915 | *Standard error* | | 0,436511 |
| *R-squared* | 0,710814 | *Adjusted R-squared* | | 0,702528 |
| *F(10, 349)* | 85,78359 | *P-value(F)* | | 9,96e-88 |
| *Log-likelihood* | −206,8132 | *Akaike criterion* | | 435,6264 |
| *Schwarz criterion* | 478,3735 | *Hannan-Quinn* | | 452,6234 |
| **Statistics based on original data** | | | | |
| *Dependent variable mean* | 135,7170 | *Residual sum of squares dependent variable* | | 322,9056 |
| *Residual sum of squares* | 37459664 | *Standard error* | | 327,6191 |

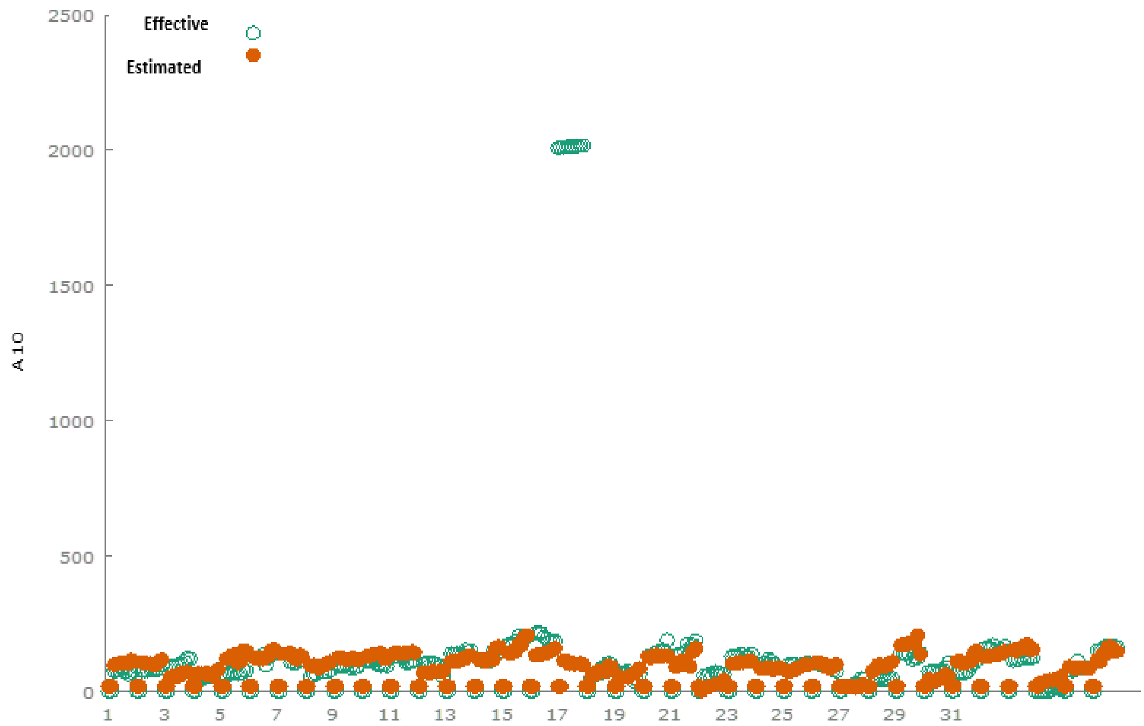



*Figure 3. Effective and estimated values in WLS regression with respect to historical series of group.*

| Fixed effects using 360 observations | | | | | |
|---|---|---|---|---|---|
| 36 cross section units are included | | | | | |
| Time series length = 10 | | | | | |
| Dependent variable "*Employment Impact*" | | | | | |
| | *Coefficient* | *Std.Error* | *t-statistic* | *p-value* | |
| **const** | 59,4123 | 1,93473 | 30,71 | <0,0001 | *** |
| **A3** | 7,91479 | 2,93075 | 2,701 | 0,0073 | *** |
| **A4** | 0,226095 | 0,0752032 | 3,006 | 0,0029 | *** |
| **A6** | -12,3058 | 3,72922 | -3,300 | 0,0011 | *** |
| **A8** | 0,406946 | 0,178816 | 2,276 | 0,0235 | ** |
| **A18** | 0,251843 | 0,0549855 | 4,580 | <0,0001 | *** |
| **A20** | 0,903777 | 0,127427 | 7,093 | <0,0001 | *** |
| **A22** | 0,368179 | 0,0916739 | 4,016 | <0,0001 | *** |
| **A23** | 0,466726 | 0,0584832 | 7,981 | <0,0001 | *** |
| **A33** | -0,322160 | 0,0751390 | -4,288 | <0,0001 | *** |
| **A49** | 0,632559 | 0,0679186 | 9,313 | <0,0001 | *** |

| | | | |
|---|---|---|---|
| *Mean dependent variable* | 135,7170 | *Residual sum of squares of dependent variable* | 322,9056 |
| *Residual sum of squares* | 94411,85 | *Standard Error* | 17,33997 |
| *R-squared LSDV* | 0,997478 | *R-squared infra-groups* | 0,869729 |
| *LSDV F(45, 314)* | 2759,558 | *P-value(F)* | 0,000000 |
| *Log-likelihood* | −1513,295 | *Akaike Criterion* | 3118,590 |
| *Schwarz Criterion* | 3297,351 | *Hannan-Quinn* | 3189,669 |
| *rho* | 0,449238 | *Durbin-Watson* | 0,828529 |

| |
|---|
| *Joint test on regressors-* |
| *Teststatistics:*F(10, 314) = 209,636 |
| *p-value* = P(F(10, 314) > 209,636) = 1,66345e-132 |
| *Group Intercept Difference Test -* |
| *Null hypothesis: the groups have a common intercept* |
| *Test statistics:*F(35, 314) = 3303,07 |
| *p-value* = P(F(35, 314) > 3303,07) = 0 |

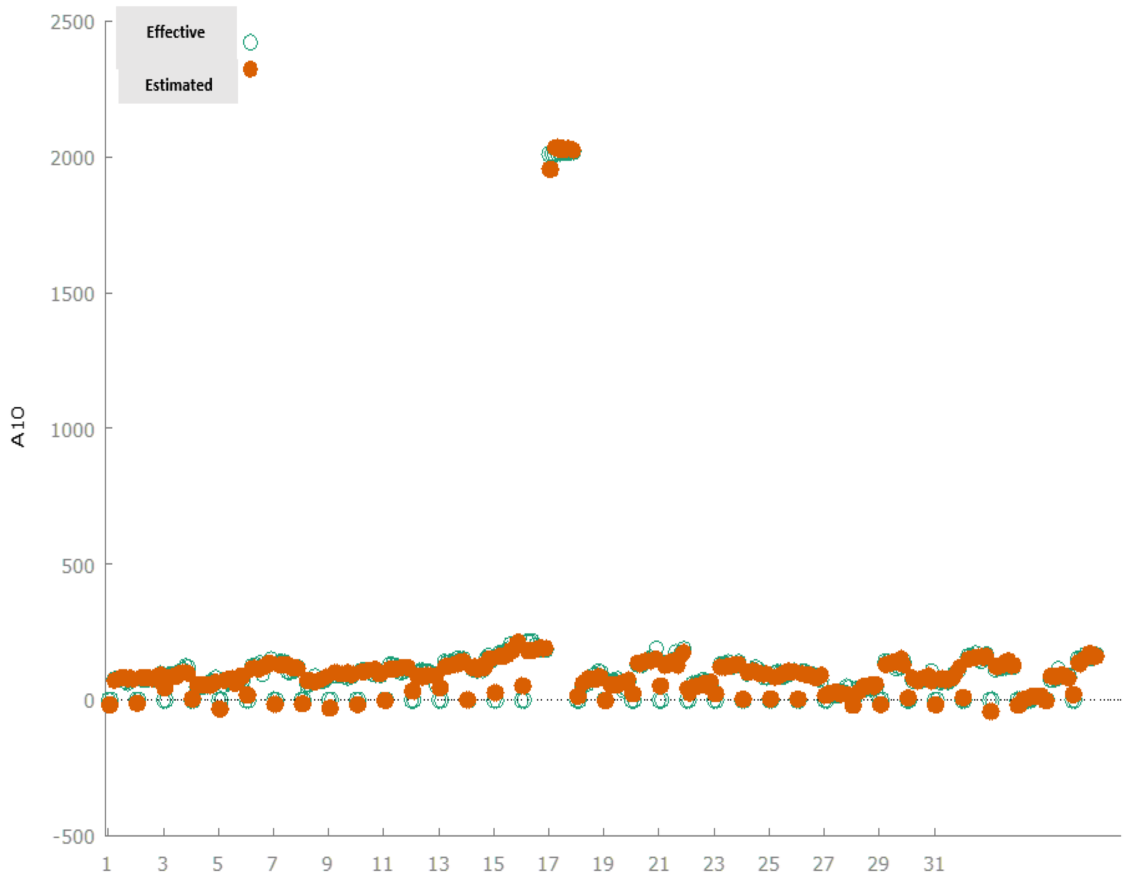



*Figure 4. Effective and estimated values in Fixed Effects regression with respect to historical series of group.*

| Random Effectsusing 360 observations | | | | | |
|---|---|---|---|---|---|
| 36 cross section units are included | | | | | |
| Time series length = 10 | | | | | |
| Dependent Variable : Employment Impacts | | | | | |
| | *Coefficient* | *Std. Error* | *z* | *p-value* | |
| **const** | 59,4287 | 58,0487 | 1,024 | 0,3059 | |
| **A3** | 7,91128 | 2,91044 | 2,718 | 0,0066 | *** |
| **A4** | 0,225677 | 0,0746517 | 3,023 | 0,0025 | *** |
| **A6** | -12,2974 | 3,70341 | -3,321 | 0,0009 | *** |
| **A8** | 0,406816 | 0,177577 | 2,291 | 0,0220 | ** |
| **A18** | 0,251780 | 0,0545901 | 4,612 | <0,0001 | *** |
| **A20** | 0,902662 | 0,126502 | 7,136 | <0,0001 | *** |
| **A22** | 0,368577 | 0,0910013 | 4,050 | <0,0001 | *** |
| **A23** | 0,465656 | 0,0580620 | 8,020 | <0,0001 | *** |
| **A33** | -0,322624 | 0,0746012 | -4,325 | <0,0001 | *** |
| **A49** | 0,634946 | 0,0674249 | 9,417 | <0,0001 | *** |

| | | | |
|---|---|---|---|
| *Mean dependent variable* | 135,7170 | *Residual sum of squares of dependent variable* | 322,9056 |
| *Residual sum of squares* | 37204945 | *Standard Error* | 326,0366 |
| *Log-likelihood* | â˜'2589,071 | *Akaike Criterion* | 5200,141 |
| *Schwarz Criterion* | 5242,888 | *Hannan-Quinn* | 5217,138 |
| *rho* | 0,449238 | *Durbin-Watson* | 0,828529 |

Variance 'between' = 122865

Variance'within' = 300,675

| |
|---|
| Theta for the transformation= 0,984358 |
| Joint test on regressors- |
| Asymptotic Test Statistics:Chi-quadro(10) = 2125,27 |
| p-value = 0 |
| |
| Test Breusch-Pagan - |
| Null hypothesis: variance of unit-specific error= 0 |
| Chi-quadro(1) = 1528,9 |
| con p-value = 0 |
| |
| Test di Hausman - |
| Null hypothesis: GLS estimates are consistent |
| Asymptotic Test Statistics: Chi-quadro(10) = 5,52064 |
| p-value = 0,853803 |

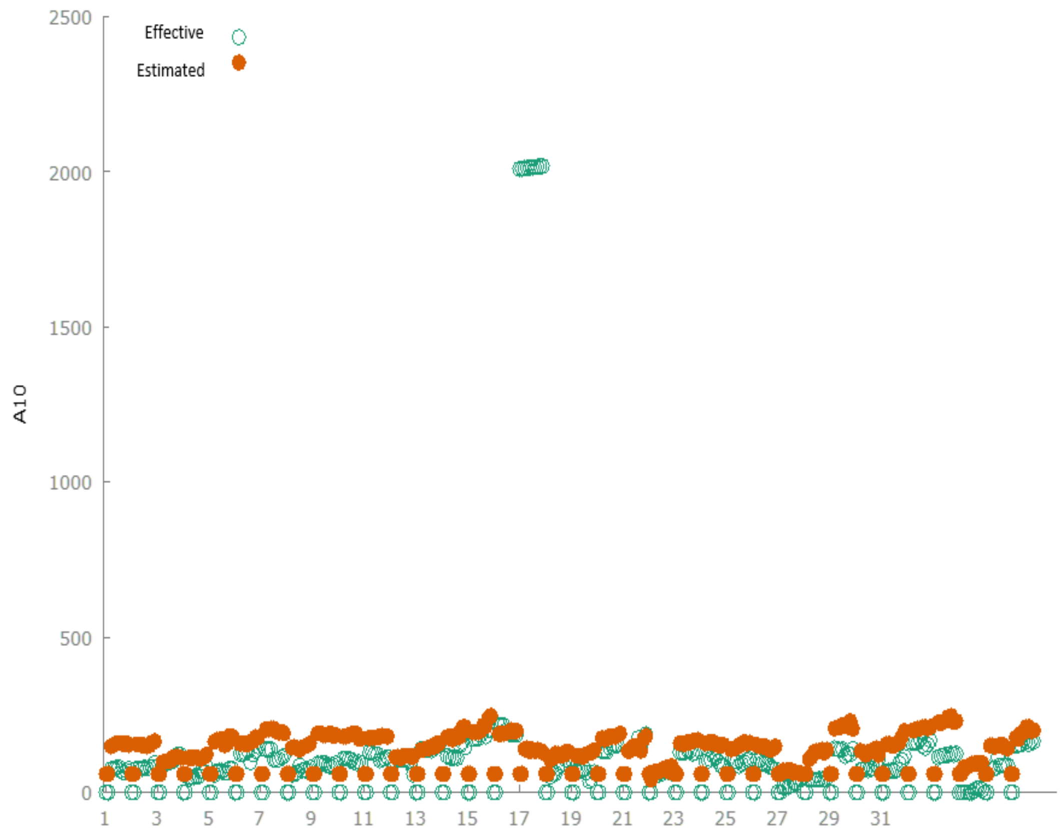



*Figure 5. Effective and estimated values in random effects regression with respect to historical series of group*

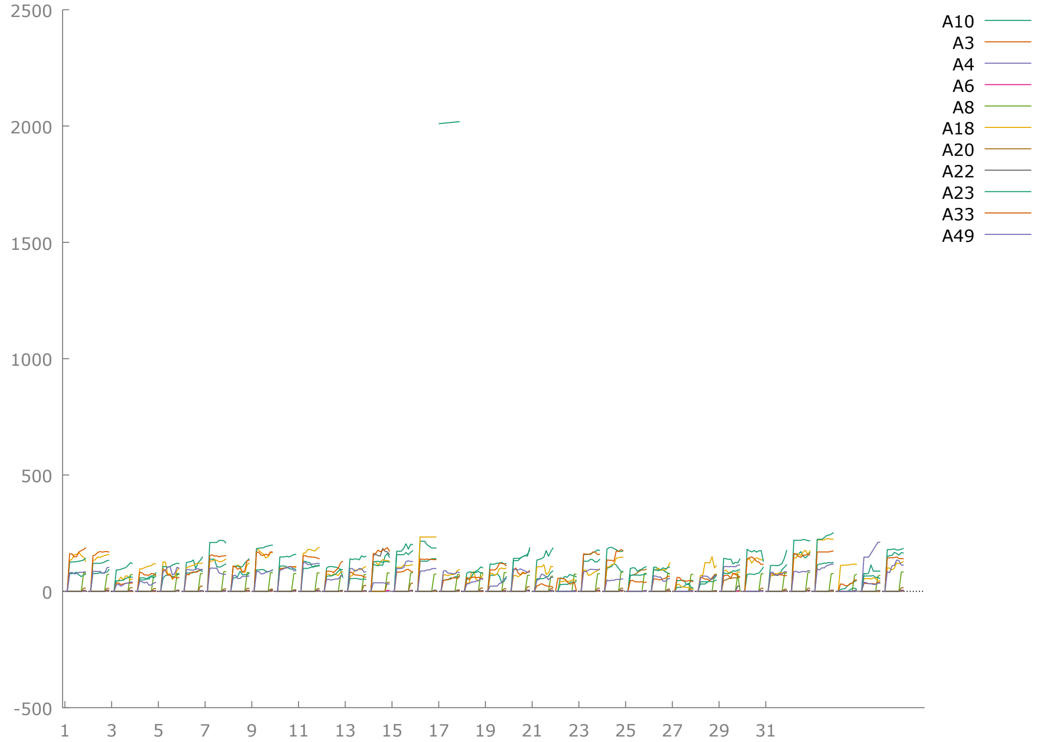
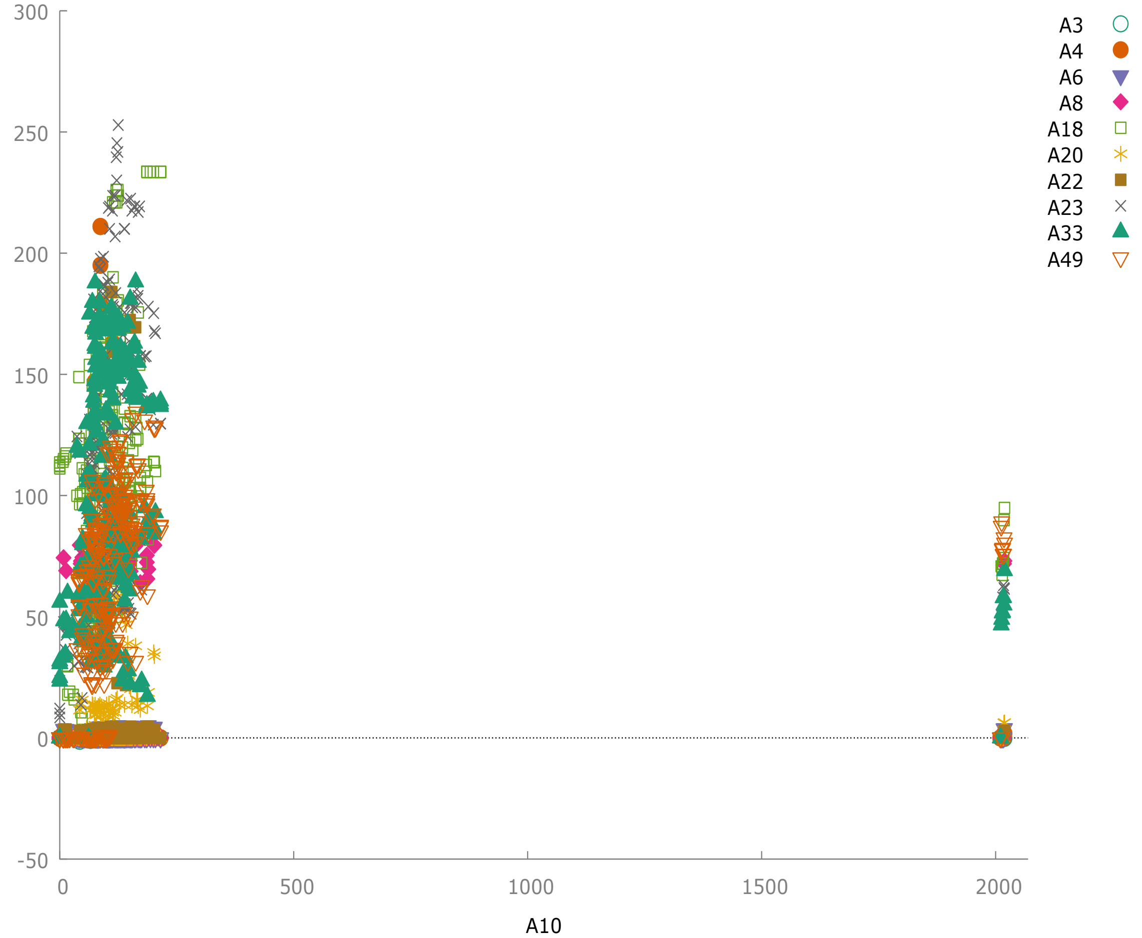
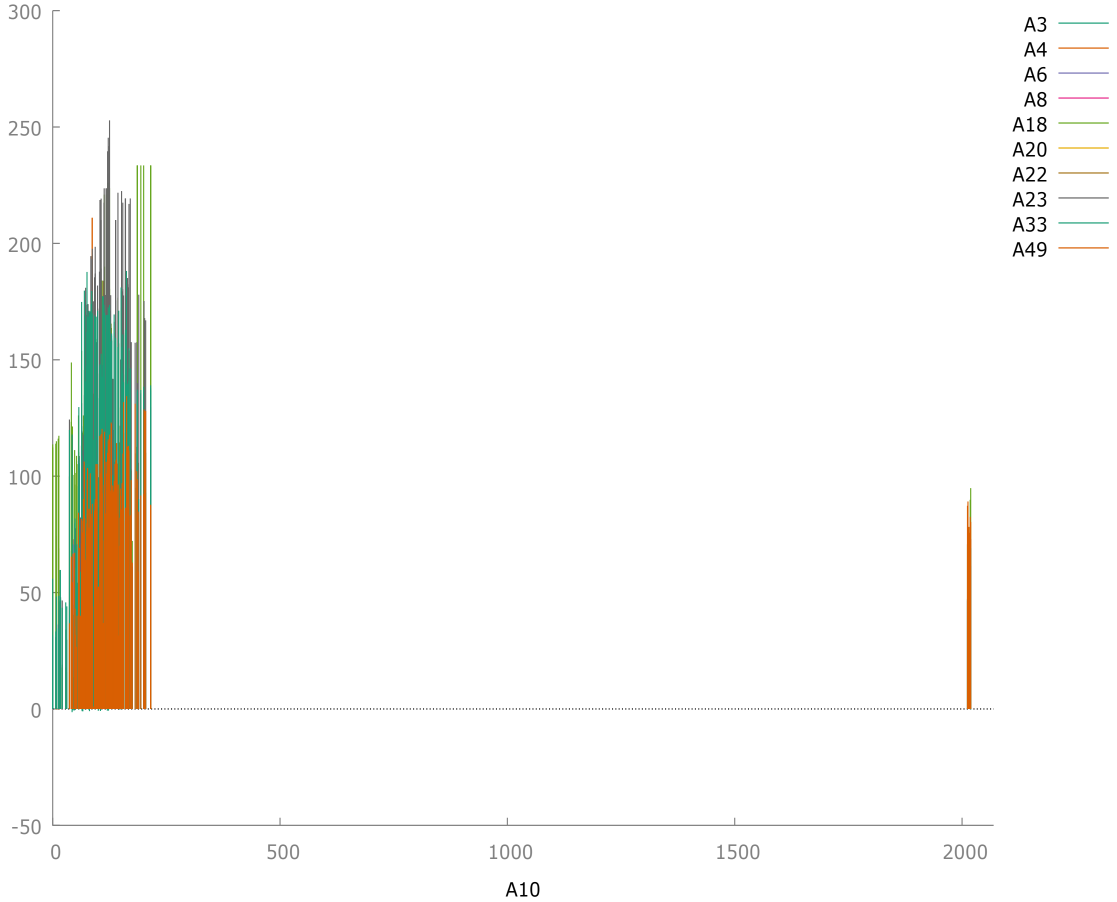
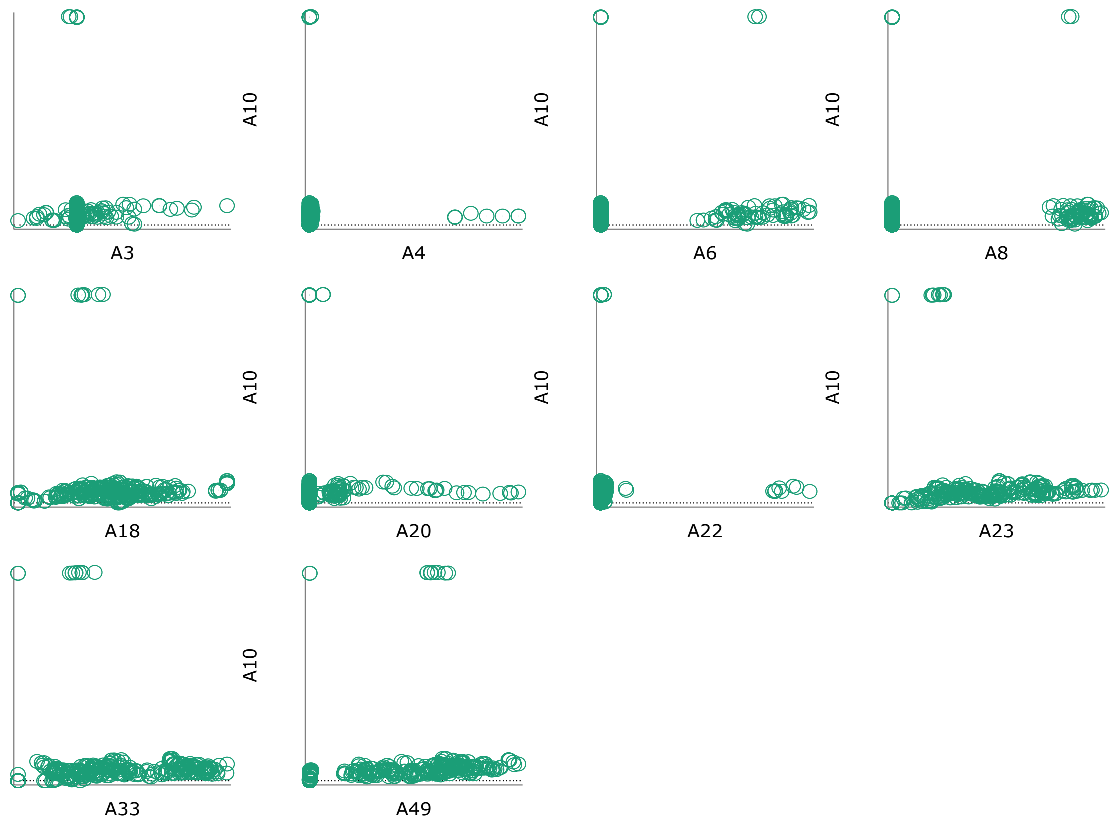
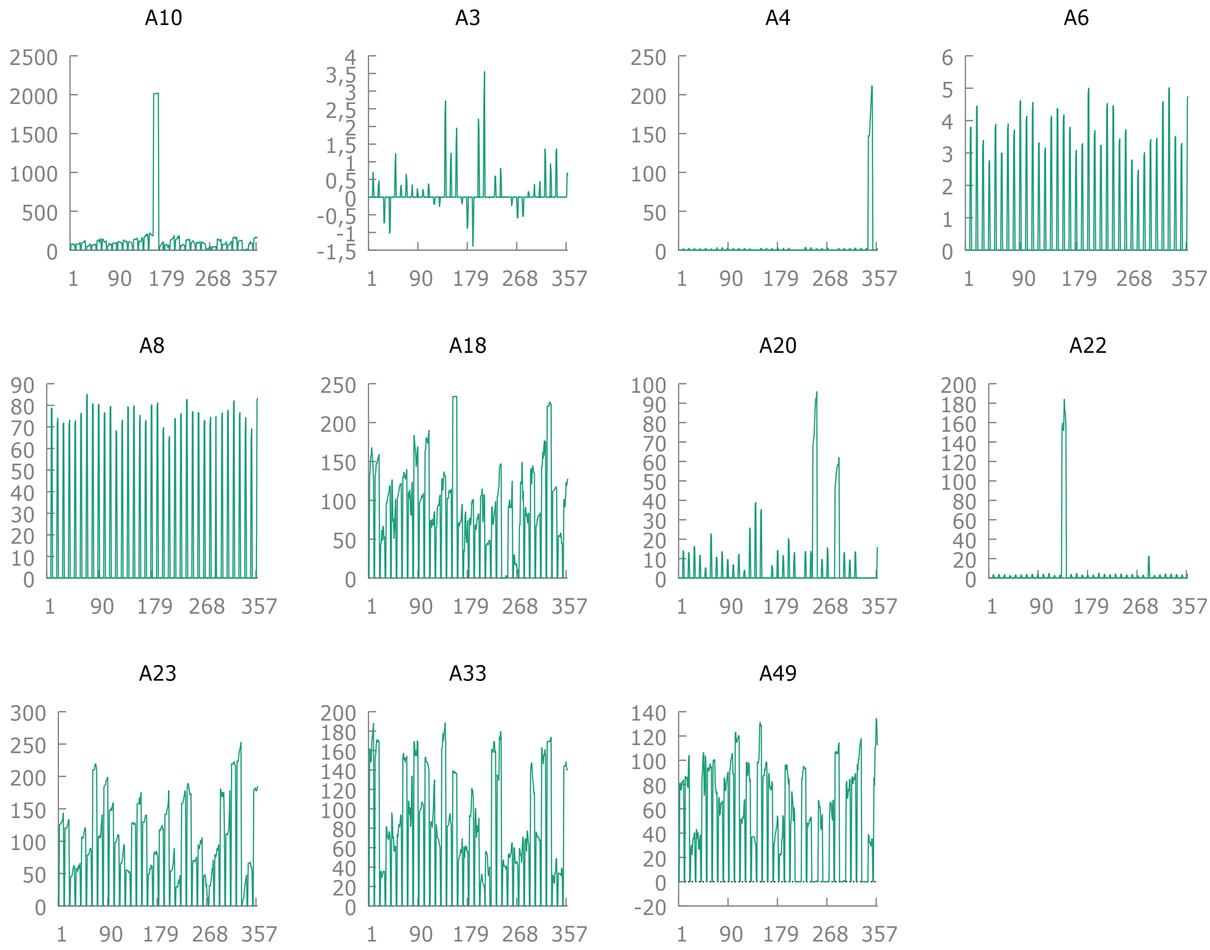



*Figure 6. Historical series for the group.*




300
250
200
150
100
50
0
-50
0
500
1000
1500
2000
A10
A3
A4
A6
A8
A18
A20
A22
A23
A33
A49


A10
A3
A4
A6
A8
A18
A20
A22
A23
A33
A49




***Correlation matrix***

| Principal component analysis | | | |
|---|---|---|---|
| n = 360 | | | |
| Analysis of the eigenvalues of the correlation matrix | | | |
| Component | Eigenvalue | Cumulative | Proportion |
| 1 | 3,7371 | 0,3397 | 0,3397 |
| 2 | 2,0570 | 0,1870 | 0,5267 |
| 3 | 1,1110 | 0,1010 | 0,6277 |
| 4 | 1,0298 | 0,0936 | 0,7213 |
| 5 | 0,9723 | 0,0884 | 0,8097 |
| 6 | 0,8293 | 0,0754 | 0,8851 |
| 7 | 0,6606 | 0,0601 | 0,9452 |
| 8 | 0,2992 | 0,0272 | 0,9724 |
| 9 | 0,2071 | 0,0188 | 0,9912 |
| 10 | 0,0813 | 0,0074 | 0,9986 |
| 11 | 0,0154 | 0,0014 | 1,0000 |

Eigenvectors (component weights)

| | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7 |
|---|---|---|---|---|---|---|---|
| A10 | -0,048 | -0,019 | -0,471 | 0,551 | 0,655 | -0,056 | -0,004 |
| A3 | -0,216 | 0,313 | 0,244 | 0,016 | 0,179 | 0,438 | 0,744 |
| A4 | 0,039 | 0,094 | -0,239 | -0,765 | 0,441 | -0,351 | 0,161 |
| A6 | -0,307 | 0,519 | -0,134 | -0,055 | -0,033 | 0,145 | -0,254 |
| A8 | -0,285 | 0,518 | -0,152 | -0,062 | -0,054 | 0,107 | -0,376 |
| A18 | -0,441 | -0,242 | -0,001 | -0,071 | 0,004 | 0,065 | -0,034 |
| A20 | -0,075 | 0,363 | 0,038 | 0,282 | -0,289 | -0,753 | 0,315 |
| A22 | -0,108 | 0,071 | 0,732 | 0,090 | 0,497 | -0,217 | -0,259 |
| A23 | -0,448 | -0,218 | 0,006 | -0,075 | -0,092 | -0,101 | 0,071 |
| A33 | -0,449 | -0,250 | 0,138 | -0,036 | -0,016 | -0,113 | -0,110 |
| A49 | -0,400 | -0,220 | -0,254 | 0,062 | -0,031 | -0,085 | 0,170 |

| | PC8 | PC9 | PC10 | PC11 |
|---|---|---|---|---|
| A10 | -0,199 | 0,002 | 0,002 | -0,004 |
| A3 | -0,059 | -0,002 | 0,081 | -0,087 |
| A4 | -0,022 | 0,026 | 0,036 | -0,004 |
| A6 | 0,029 | -0,053 | 0,015 | 0,724 |
| A8 | 0,023 | -0,013 | -0,017 | -0,683 |
| A18 | -0,066 | 0,809 | -0,277 | 0,024 |
| A20 | -0,070 | 0,162 | -0,001 | -0,001 |
| A22 | 0,239 | -0,052 | -0,136 | 0,010 |
| A23 | -0,380 | -0,524 | -0,550 | -0,009 |
| A33 | -0,306 | -0,080 | 0,768 | -0,014 |
| A49 | 0,807 | -0,178 | 0,057 | -0,025 |

***Descriptivestatistics, using observations 1:01 - 36:10***

| Variable | Mean | Median | Minimum | Maximum |
|---|---|---|---|---|
| A10 | 135,72 | 87,012 | 0,0000 | 2019,0 |
| A3 | 0,083990 | 0,0000 | -1,3885 | 3,5501 |
| 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 |
| A18 | 84,483 | 89,888 | 0,0000 | 233,51 |

| | | | | |
|---|---|---|---|---|
| A20 | 5,2816 | 0,0000 | 0,0000 | 95,842 |
| A22 | 4,3792 | 0,0000 | 0,0000 | 183,97 |
| A23 | 90,897 | 84,007 | 0,0000 | 252,86 |
| A33 | 78,414 | 70,374 | 0,0000 | 188,19 |
| A49 | 52,107 | 54,227 | -0,25937 | 134,39 |
| Variables | Standard deviation | Coefficient of variation | Asymmetry | Kurtosis |
| A10 | 322,91 | 2,3793 | 5,4749 | 29,021 |
| A3 | 0,45166 | 5,3776 | 3,6663 | 20,381 |
| 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 |
| A18 | 61,263 | 0,72515 | 0,24491 | -0,41895 |
| A20 | 15,323 | 2,9011 | 3,8776 | 15,680 |
| A22 | 24,031 | 5,4875 | 6,4562 | 40,202 |
| A23 | 68,080 | 0,74898 | 0,26828 | -0,91544 |
| A33 | 58,614 | 0,74749 | 0,20037 | -1,2255 |
| A49 | 41,619 | 0,79871 | -0,029395 | -1,4204 |
| ***Variables*** | ***5% Perc.*** | ***95% Perc.*** | ***Range interquartile*** | ***Missing values*** |
| A10 | 0,0000 | 193,59 | 85,714 | 0 |
| A3 | -0,15945 | 0,80776 | 0,0000 | 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 |
| A18 | 0,0000 | 184,03 | 85,907 | 0 |
| A20 | 0,0000 | 37,863 | 0,0000 | 0 |
| A22 | 0,0000 | 4,0707 | 0,0000 | 0 |
| A23 | 0,0000 | 217,47 | 105,44 | 0 |
| A33 | 0,0000 | 170,17 | 105,20 | 0 |
| A49 | 0,0000 | 113,43 | 88,200 | 0 |