Effects of The Innovative Effort on the Innovative Output in The Spanish Regions

Highlights

- The innovative output of firms depends on internal and external factors that affect their innovative effort.
- The relationship between innovative effort and innovative output differs at the micro level (firms) between Spanish regions.
- The formulation of innovation policies should emphasize the involvement of different social groups at the regional or national level.

ABSTRACT

This paper aims to analyze the effects of innovative effort on innovative output by using data from (12,849 firms) in Spanish regions. The research uses a descriptive-analytical method to test the study hypotheses, as well as a comparative method to discover the similarities and differences among the Spanish regions. The source of data is the Technological Innovation Panel (PITEC) of the Ministry of Economy and Competitiveness of Spain. The results of the logistic regression demonstrated the positive effects of innovative effort on innovative Output, with regional differences. Based on the results, the study recommends establishing coordination between public or private research and training centers with an emphasis on the participation of all social groups, both at the national and regional level to formulate innovation policies adapted to each business environment.

keywords: ***Innovative Effort, Innovative Output, R&D expenditure, Patent, Spain.***

1. Introduction:

Achieving greater productivity requires innovation because it benefits the company, the industry, and the country in which it operates (Acuna-Opazo & Castillo-Vergara, 2018), economic growth is strengthened and encouraged by innovation (Nawrocki & Jonek-Kowalska, 2023), innovation presents new options for wealth generation to resources and is seen as an exogenous component of economic growth (Michalak & Wolniak, 2023), the impact of paying attention to the management of innovation effort's role in organizations cannot be concealed in the activation, attention, and quality of workers' roles through the formation of intellectual capital capable of dealing with the organization's internal and external conditions (Idris & Durmuşoğlu, 2021).

In addition to that, innovation is a crucial component for organizations, the impact of innovation on society and infrastructure cannot be ignored (Zhang et al., 2019) as it has been demonstrated that innovation is crucial to both a nation's development and the survival of businesses (Har et al., 2021), also organizational elements support and facilitate innovation (Pylypenko et al., 2023), for this reason, efficient investment in innovation will allow obtaining optimal results and in turn achieving improvements in the organization of the company, efficiency in management and above all obtain competitive advantages that generate consolidation in the market (Aguirre-Campoverde et al., 2021), if a firm carries out a higher number of activities related to the internal organization or the external collaboration for innovation, then it reaches higher productivity (Rumanti et al., 2023). This positive effect is bigger when a firm collaborates with universities and/or technology centers and employs recent college graduates, especially those with degrees in science, engineering, or technology (Sánchez-Sellero et al., 2015).

Due to increased global competition (Maqdliyan & Setiawan, 2023), there is more pressure to be successful in gaining new markets while also having items that can rival newly arrived goods from other nations that may have cheaper pricing or stand out from the competition (Del-Aguila-Arcentales et al., 2023). Furthermore, organizations are motivated to innovate to improve their capacity to satisfy new requirements through new products, services, and processes (Rajapathirana & Hui, 2018); on the other side, this promotes economic growth and increased social welfare. The use of materials in production lines, which in turn achieves the least use of resources since doing so secures their sustainability, reduces waste and uses resources for future generations, is another obvious function it plays in the organization's optimum use of the resources available (Zhang et al., 2019). Consequently, when labor expenses are decreased, resources are spared, and money is available for investments in innovative products and technologies (Pylypenko et al., 2023).

Some are wondering: Why does innovation happen in certain places and not elsewhere? What are the contextual conditions and general interventions that enable such innovations to occur in a particular location?

Location-based innovation helps to identify the most appropriate "policy mix"; in the process of discovering entrepreneurs in a given region (Szerb et al., 2020), the regional dimension of innovation is emphasized by focusing on the ecosystems of place-based innovation (Rissola, & Haberleithner, 2020), which must take into account the concept of intelligent specialization adopted in Europe through regional, economic power, collective intelligence, and specific assets -based research and innovation strategies (Rissola et al., 2017).

The analysis of innovation systems is simpler at the regional level. Identification of economic policies at the regional level rather than at the national or international level (Ponsiglione & Quinto & Zollo, 2018). Studies on the subject are based on the study of innovation within national boundaries, namely, that the nature of work and research in international companies is an integral part of the host country's local business networks and national or regional innovation systems, which means integration between the internal and external networks of the international organization and is an emphasis on the specificity of the territory, as well as an emphasis on the culture of the organization (Paoanastassiou et al., 2020).

To take into consideration the differences among regions that emphasize strong supportive institutions and political capacities at the regional level, the place-based policy strategy explicitly calls for the use of local knowledge and improved learning within the region's policy, it recommends that the same regions design and implement policies for their knowledge of the region, where there is no regional innovation policy. Also, regional governments are heterogeneous in their ability to deal with this level of policy complexity (Morisson & Dossineau, 2019).

There is no doubt that innovation effort is a key element for the growth of the Territory, so the European Commission in 2014 approved that, stimulating innovation effort in companies is a priority on the agenda of organizations that aim to promote growth and sustainable development in the region (López-Bazo & Motellón, 2018). Especially after science began to employ the "national innovation system," which portrays innovation as a continuous process including several stages, from the emergence of an inventive concept to the spread, absorption, and application of novel goods (Pylypenko et al., 2023).

There is a need for an integrated approach to understanding the dynamics of place-specific knowledge, and the centrality of entrepreneurship in the local innovation system to the process of discovering entrepreneurs, by considering how to empower actors in innovation effort processes in a way that mobilizes the implicit knowledge of stakeholders and integrates it into decision-making (Rissola et al., 2017).

Therefore, the novelty of research comes from the approach to the ongoing debate regarding the impact of independent variables on innovation outcomes. By utilizing comprehensive data

covering a longer period, the study aims to achieve more detailed and accurate results specifically applicable to the Spanish environment. This approach allows for the capture of dynamic relationships between the exploratory variables, providing a deeper understanding of both their strengths and weaknesses compared to studies relying on cross-sectional data, time series data, or short-term panel data with limited samples, Ultimately, the research seeks to promote a more effective environment for fostering innovation in Spain.
As aforementioned, this paper investigates the effects of the innovative effort on Innovative output The case of the Spanish regions depends on empirical study.

2. Literature review:

2.1 The Role of the innovative effort on the innovative output.

A company's organizational structure, lack of resources, or lack of experience can all be considered internal barriers to innovation that keep them from actively implementing changes (Bataineh et al., 2023).
Even though innovation efforts are important, there is debate over which indicator is more effective, for instance, the relationship between research and development and innovation remains unclear; ambiguity in their relationship is that increased research and development does not necessarily mean greater innovation in the organization, either through research between different organizations or through research based on micro-sourcing or outsourcing (Vrontis & Christofi, 2021).
External territorial determinants are represented in existing organizational infrastructure, the legal atmosphere, and the industrial cities the existence of technological agglomerations (Lin et al., 2021), and the existence of universities and research institutions, which are represented by educational zones. Learning systems, which can deal with organizations and identify the most important opportunities and challenges for innovation through consensual research with organizations in the region, is the presence of an innovative community. It should be noted that the impact of these external factors should be identified through the performance of innovation in the organization itself rather than through regional data, all the internal and external determinants mentioned interact with each other to produce innovation outputs at the regional level (López-Bazo & Motellón, 2018).
The creation of a knowledge-based economy requires the expansion of policy instruments aimed at the formation and mobility of human resources in science and technology and the easy flow of qualified people between universities and corporations (Schot & Steinmueller, 2018) because the general assumption is that: the interaction between universities and companies promotes the generation, and accumulation of knowledge, and the facilitation and application of knowledge within the innovation system. The first national plan was adopted in 1986, bringing about many changes: the gradual introduction of new planning tools, the adaptation of research, development and innovation policies, and the detection of the special needs of the Spanish science, technology and innovation system (Alvarez et al., 2018), because the ability to innovate stems from the collective ability of employees to share knowledge between themselves and clients, facilitated by the currently existed technology and Internet (Soto-Acosta et al., 2016).
We give an example of how the Basque Country has promoted corporate competitiveness and supported innovation in various organizations, given the Spanish Constitution's autonomy over the Basque Country, which came about in. (1978), which then led to the election of the Territory's first privately formed pragmatic government. Protectionist policies and the opening up of the Spanish economy affected a deep industrial crisis in the Basque economy, leading to massive unemployment and social unrest. The first Basque government was able to implement industrial policies specifically designed to support the industrial restructuring of the Basque region, called the Basque Region. First great transport, and in 2006, the Basque Government

promoted innovation and enhanced competitiveness in the Territory (2016) to be the second richest region in Spain in terms of per capita GDP from Madrid €32,621 compared to €23,970 for Spain (Morisson & Dossineau, 2019).
Accordingly, the first main hypotheses could be formulated:
Hypothesis 1. The internal innovative effort of companies positively influences overall innovative output.

Companies' investment in internal R&D is one of their advantages in generating creative ideas and improving their capacity to perceive, comprehend, and use knowledge. Also, it enhances one's capacity to absorb innovation's effects (Aguirre-Campoverde, et al., 2021), because Entrepreneurship and creativity are the cornerstones of innovation. They are the inspiration behind the development of fresh concepts into novel goods and services (Nawrocki & Jonek-Kowalska, 2023).
A company's organizational structure, lack of resources, or lack of experience can all be considered internal barriers to innovation that keep them from actively implementing changes (Bataineh et al., 2023), for It is crucial to prepare the internal infrastructure (Kushnir et al., 2020).
Studies and researchers have emphasized the significance of internal rather than external organizational determinants, demonstrating that internal rather than external organizational elements are of greater interest and focus (Carboni & Medda, 2021), which should result: in supporting diversity and social interactions, encouraging group learning and co-evolution and implicit knowledge of innovation performance, enhancing innovation policies, building strong trusting relationships, investing in a superior and unique knowledge base, and ensuring that innovation policies are a crucial component of the local context and concentrate on regional specifics (Lopes et al., 2021), therefore industrial zones are built on promoting knowledge, and connecting science to creative activity in organizations (Boschma, 2022).
Spain has incorporated the organization of the innovation strategy in Andalucía into the first Spanish law on science and technology (Ley 13/1986), which sets out the basis for a national innovation strategy and also recognizes the various administrative regions of Spain (A total of 17 Comunidades Automas) have the legal capacity and autonomy to develop their regional innovations, always in line with European and Spanish innovation policies (Alvarez et al., 2018), at the end of the 1980s, attention was paid to regional integration and the process of convergence through same levels of education, homogeneity of productive structures and technological catch-up in Andalucía, because of the European view that Spanish regions are technologically marginal. The increase in R&D expenditure compared to the European Union average has been done under the European Structural Funds to link this R&D investment to a regional policy within the country that focuses on reducing technological disparities. With all these policies, the technology gap is still significant, and the gap comes about because knowledge needs time to be developed and intellectual capital is in many stages of coming up with useful knowledge for different organizations, which means taking advantage of other knowledge processes as well, with emphasis on different regions. The innovative processes in Spain are European-compatible and not different and are part of the integrative view of the Euro 2020 Strategy (Solov'eva et al., 2018).
Andalucía has developed several innovation plans: The first was the steering plan for innovation and technological development 2001-2003, the third plan for Research in Andalucía 2000-2003, and the plan for research, development, and innovation 2007-2013. Finally, Andalucía implemented the development and innovation plan (PAIDI 2014-2020) R & D should become the main instrument for planning, coordinating, promoting, and evaluating R & D and innovation in the region, with the formulation of regional PAIDI aimed at laying a solid foundation for a new paradigm based on knowledge, innovation, and the use of material and

human resources for job creation, as well as sustainable development and social cohesion. Its main objectives are to encourage innovation - particularly regarding the growth of the economy, modernization of traditional production, and to be a model compatible with national and European strategies for innovation, technology, and science. PAIDI focuses on a range of sectors identified as a strategy for the development of the region, such as ICT, energy, food, industry, any other priority sector that promotes technology development, and the integration of high-quality competitive research aimed at improving science, technology, and innovation indicators at the regional level (Alvarez et al., 2018).

Hypothesis 2. The external innovative effort of companies positively influences overall innovative output.

Differing views on the impact of external factors on organizational innovation; some studies have demonstrated the impact of R&D on innovation, but some studies have not. The impact on cooperation in innovation activity in the region, not on innovation of the organization, is overall in the disagreement between these determinants (López-Bazo & Motellón, 2018), and applied studies have demonstrated that there is an innovation effect on regional knowledge because applied knowledge in research forms the recognition and utilization of extra-territorial knowledge (Miguelez & Moreno, 2018), which in turn positively influences innovation output in organizations, the stimulation of R & D, and the application of new ideas to the formation of new sectors (structural change), changes in production structures, and gradual expansion of activities (Morris, 2018).

The innovation policy of the European Union is based on the concept of intelligent specialization of regions: regions must focus on their relative strengths, by mediating their place or by having strong transport routes or seaports that are a point of strength depending on the project to be done. The appropriateness of regional proximity to trade is an important thing in innovation over science that is not the only one. There is regional development to improve the effectiveness of R & D policies, and to develop R & D policies alongside other policies that focus on improving the social, economic, and structural determinants of regional innovative performance (Song & Wen, 2023), that innovation centered on a particular location or what is known as spatial innovation comes from the local capacity to innovate in a given region, the diffusion of knowledge in a given place and the shift to many policies that help to make knowledge available within a given region have an important impact on innovation processes, The role that geographical space can play in disseminating technological knowledge, both within and between regions, cannot be limited to geographical proximity, but rather technological availability of knowledge. (Papanastassiou et al., 2020), the regional innovation system is based on the interaction of parties within the region, its relationship with external parties at the state and global levels, taking into account the industrial structure of the region as well as small and medium-sized enterprises and the adoption of different sources of knowledge such as academic and scientific institutions to provide a high degree of diversity (Alvarez et al., 2018).

Spatial and temporal aspects are made allowance for in determining the spread of innovation among regions; geographical proximity to the producers of innovation, the existence, availability, and flow of knowledge through electronic space (Yan et al., 2022), finally the regional interaction of knowledge flow, while emphasizing that a place adjacent to innovative areas helps to innovate, plays a major role in the dissemination of knowledge culture that helps to create innovation within the region adjacent to the innovative territory (Chaminade et al., 2021), taking as well as taking into account the region.

Hypothesis 3. The public financing of companies positively influences innovative output.

which may come from internal or external sources to R&D efforts is substantial; assets, reserves, and capital are all considered to be internal Financing; External Financing consists of loans, national and international foundation grants, joint ventures, and R&D assistance from the government (Sánchez-Sellero & Bataineh, 2022), government assistance to R&D in companies is the primary issue affecting Spain's success in terms of innovation (Giménez-Medina et al., 2023).

Attention at the European Union level was region-specific, and the European Commission did the work of the European Cohesion Policy in (2018) to allocate the bulk of its budget to Smart Space Strategy (S3) which supports and prioritize regions in the necessary innovation and technology sectors through the process of exploring leadership, and in the concept of (regional innovation system (RIS), which is based on a systematic analysis approach to investigate innovation within regions, and where it has been concluded that there is no innovative policy suited to all where regional information varies considerably in addition to the different innovative capabilities and industrial base within regions, the place must be considered as a specificity of innovation, and the response of organizations must be taken into account because of the specificity of the place because of its different institutions and capacity to receive financing and quality of services provided (Morisson & Dossineau, 2019).

Hypothesis 4. The personnel in the R&D department of companies positively influences innovative output.

Companies need qualified personnel who can adjust to changes in their working environment (Martínez-Sánchez et al., 2020), so a geographical area must be aligned with the existing supply of trained personnel and space required as well as the need for resources and business inputs, which means that it may have a negative or positive impact on the concentration of certain types of activities in limited areas that result in a state of satisfaction in the region (Klimek, 2018).

Most of the literature sees R&D and internal capacities as necessary that are represented through the employee's skills inside the company (Vincenzi & da Cunha, 2021) to produce the company's innovative output. As a result, people who are focused on research and development are a source of ideas since their expertise helps provide the groundwork for potential new ideas (Aguirre Campoverde, et al., 2021). Furthermore, recruiting people in a corporate setting who have experience with R&D (Acuna-Opazo & Castillo-Vergara, 2018), and retaining highly qualified personnel (Rosell -Martinez & Sanchez-Sellero, 2012).

Hypothesis 5. The cooperation with external agents of companies positively influences innovative output.

Companies are aware of the need to form R&D collaboration ties when they engage in innovation processes with various economic agents, such as subsidiaries, customers, suppliers, agents, institutions, and others. This is done to produce output that cannot be produced within the same organization, companies can gain access to a variety of sources and share resources, such as: splitting costs and risks, as well as distributing the labor of the innovation process, by entering into cooperation agreements or alliances with external economic agents (Aguirre Campoverde, et al., 2021). The outcome advantages of collaboration for businesses' innovation efforts are numerous: reducing the time it takes to innovate, hastening the commercialization of products, sharing costs and risks, getting access to resources that are complementary or comparable, and getting access to outside knowledge (Radicic et al., 2019), in addition, innovation plans are more successful if companies can obtain, transform, and utilize external knowledge (Carrasco-Carvajal et al., 2023).

Outsourcing based on local specialized suppliers allows for flexible and light production, as well as easy access to consulting. Agglomeration economy and spatial proximity allow for

visual examination of consumers and possible cooperation in vertical relationships such as those between organizations, customers, and suppliers, while horizontal competition between organizations with similar disciplines stimulates diversity and efficiency (Li et al., 2019).
The importance of the existing vertical relationship with suppliers, clients, and competitors and the essential element of cooperation partners and external sources of knowledge. Cooperation with universities and organizations is characterized as a process of collaboration with suppliers and supplier/client relations. On the one hand, universities provide new ideas to organizations through the creative ideas offered by universities for productive work, and university students are potential or real clients, as well as opportunities to learn about the competitors and their best outcomes, trying to beat them or keep up with them at work is one of the catalysts of the innovation process (Ikeuchi, 2015).

Hypothesis 6. The innovative effort of companies differently influences innovative output in the Spanish regions.

Innovation is viewed as the cornerstone of knowledge-based, sustainable economic development in the European Union, which guarantees social well-being. Even with the numerous measures made to enhance innovation (Brodny et al., 2023).
The innovation policy of the European Union is based on the concept of intelligent specialization of regions: regions must focus on their relative strengths, by mediating their place or by having strong transport routes or seaports that are a point of strength depending on the project to be done. The appropriateness of regional proximity to trade is an important thing in innovation over science that is not the only one. There is regional development to improve the effectiveness of R&D policies and to develop R&D policies alongside other policies that focus on improving the social, economic, and structural determinants of regional innovative performance (Vakhovych et al., 2021).
That innovation centered on a particular location or what is known as spatial innovation comes from the local capacity to innovate in a given region, the diffusion of knowledge in a given place, and the shift to many policies that help to make knowledge available within a given region have an important impact on innovation processes, The role that geographical space can play in disseminating technological knowledge, both within and between regions, cannot be limited to geographical proximity, but rather technological availability of knowledge. (Papanastassiou et al., 2020), the regional innovation system is based on the interaction of parties within the region, its relationship with external parties at the state and global levels, taking into account the industrial structure of the region as well as small and medium-sized enterprises and the adoption of different sources of knowledge such as academic and scientific institutions to provide a high degree of diversity (Alvarez et al., 2018), also the facilities in government legislation (Tania et al., 2022).

2.2 The Conceptual and empirical complexity of the innovative output:

The concept of innovation is unclear because it is viewed and studied through different approaches: technological, organizational, administrative, human, productive... etc (Lee & Trimi, 2018), it is treated as a shift of new knowledge and ideas in new products and/or services, new technologies, new processes and organization (Soto-Acosta, et al. 2016), upgrade and introduce new products (Reddy & Sasidharan, 2023) and enhancing the capabilities of firms (Le & Le, 2023), but there is a relation between innovation effort and productivity growth in organizations (Morris, 2018) reflected on performance (Larios-Francia & Ferasso, 2023).
The goal of innovation policies is to encourage the creation of novel concepts and technological advancements that boost output and value while requiring less input, as well as in Spain. Innovation, technical advancement, and economic expansion are interrelated (Giménez-Medina et al., 2023), while innovative product or services are the output that is commonly

linked with innovation, and it is exemplified by the introduction of new products and services (Kahn, 2018). Patent registration is common as the output of innovation although not all inventions are registered in companies, and in Spain there is Eurostat's New Cronos data provides information on patents, which allows analysis only of Spanish companies, which has been observed to show that there was a marked increase in the rates of patronage of Spanish organizations in the second half of the 1990s. The province of Cataluña ranked first in patents (1995 -2001), followed by Madrid, then Valencia, and La Rioja came last (Cabrer-Borras & Serrano-Domingo, 2007).

Researchers have found that the impact of R&D on patents varies depending on the patent's quality. Similarly, the impact that firms have on productivity is mostly determined by the quantity of patents they have previously obtained. As a result, businesses that begin the innovative process early on will receive more patents and be better able to assimilate new concepts.

Achieving improved outcomes when growth is primarily driven by innovation, and the ability to innovate and produce is strongly correlated with the number of patents it has. The main advantage of patents is the wide distribution of the innovation they describe, which promotes innovation diffusion and amplifies the impact of the innovation on the productivity of other businesses and the economy as a whole (Acuna-Opazo & Castillo-Vergara, 2018).

The innovative output was also learned through knowledge based on the creation of used and patented technology innovations linked to trade data on a particular region and obtained through the International Patent Classification, which includes the European Intellectual Protection Office (Miguelez & Moreno, 2018).

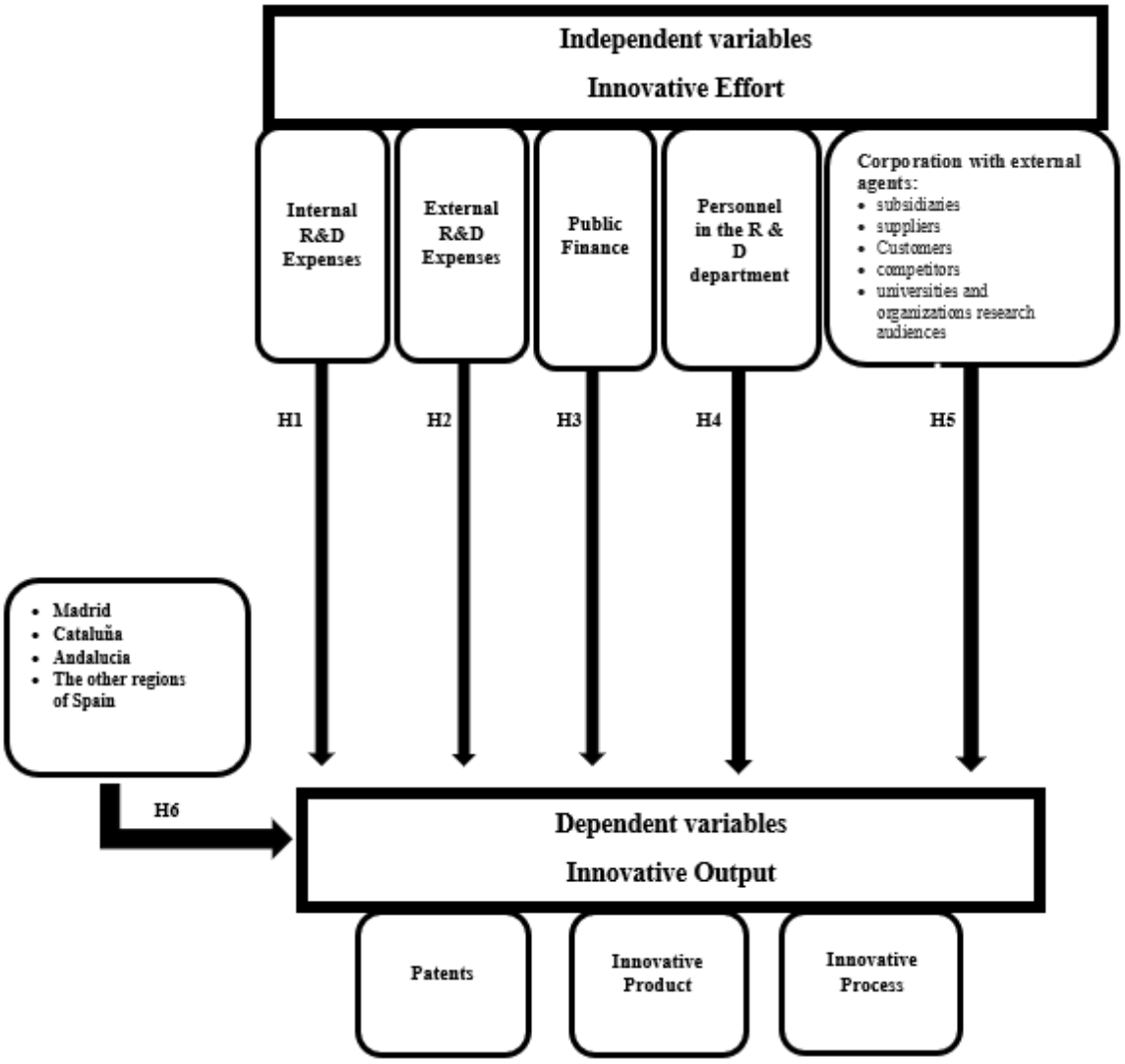
It is assumed that process innovations lower production costs by raising capital and/or labor productivity. The development and use of process innovations are factors in the relationship between R&D operations and productivity growth. The productivity increase is also contingent on the size of the company; small businesses experience a boost in productivity as soon as they introduce new procedures, sometimes even in the year that the procedures are established. Conversely, large businesses may need to wait up to two years after implementing the new process before noticing an increase in productivity (Acuna-Opazo & Castillo-Vergara, 2018).

In the Basque province, which in 2016 was ranked first in Spain and Southern Europe in European regional Innovative output, the Basque Government is the most important indicator for measuring the success of its innovation policies. Although the Basque Country of Spain ranks first in Spain and Southern Europe in the European regional innovation scoreboard, in 2012 the Basque Country experienced a decline in innovation indicators, raising questions about the model of the Basque Although the region is one of the most organizationally intensive in the European Union, the decline in its innovation indicators was due to a lack of restructuring due to its dependence on political interests, which led to a failure of coordination, leading the system to suboptimal Innovative output, with the regional elite committed to promoting innovation, which in turn led to unnecessary institutional confusion and complexity Union (Morisson & Dossineau, 2019), nonetheless, Spain has not innovated as much as its rivals in Europe (García et al., 2018).

There has been a sharp decline in various innovation indicators, such as R & D spending as a percentage of GDP and patent applications, and as a result, the Basque Country has avoided the problem of industrial competitiveness innovation policies fully funded by the Basque government with a budget (€30,582,440) for 2016 and 66 full-time staff, working in three main areas of work: technology and innovation efforts, business promotion, internationalization, and support for industrial companies and research centers to improve their innovative capabilities through and generation of patents and practical and regulatory innovations, coordinated with 1,500 private sector partners (73%), and (15%) from universities and research centers, (12%) from the public sector and civil society to form action groups to identify weaknesses in the

Basque region with regard to technological innovation, social innovation, and entrepreneurship, as well as to work to internationalize Basque companies and transform the territory in (2030) to reference in innovation in the European Union (Morisson & Dossineau, 2019)For the above, patents can be said to be the original indicator of innovation output (Morris, 2018). As mentioned before, that will use patents in the current study.
The theoretical framework is summarized in figure 1.

Figure 1. Study Prototype.



Source: own elaboration depending on previous studies regarding the study subject.

3. Data, model, and methodology:

3.1. Data:

The study methodology depends on the descriptive-analytical which allows a description of the innovation effort through the researchers' contributions, use of the other country's experiments, also use of the analytical method to analyze data that will be collected from the study population, which ultimately leads to using the comparative methodology to know the similarities and differentiation in Spain regions.
Using the data provided by the Technological Innovation Panel (PITEC) of the Ministry of Economy and Competitiveness of Spain, PITEC is the finest dataset to track innovation activity over time in Spanish businesses (Díez-Vial & Fernández-Olmos, 2015). The analysis is carried

out with panel data from 12,849 Spanish companies during the period 2003 to 2016 (because the PITEC contains only data from 2003 to 2016), to explore the effect of innovation inputs on outputs, through the independent and dependent variables, therefore will explain models going to be proposed through econometric statistical methodologies that are going to be applied for data; that is represented by annex 1, The companies places are divided four categories: Madrid, Cataluña, Andalucía, the other regions of Spain, that works in around 50 fields.

3.2. Model, and methodology:

Traditionally, the work on panel data has concentrated on generalizing these to multiple latent factor models that are identical to the low-rank factorizations (Athey & Imbens, 2019). The next models are a production function that contains the effects of innovative effort on innovative output, through the differentiation of geographical areas in Spain (Madrid, Cataluña, Andalucía, and other regions of Spain), Logistic regression is employed in this study because it effectively classifies data into distinct groups by identifying relationships within a given set of labeled data. The choice of the logistic function for binary classifications is well-founded. It possesses the unique ability to transform any real number into a probability value between 0 and 1. Logistic regression leverages these datasets to build robust prediction models (Zaidi & Al Luhayb, 2023).

Estimating the study models by following three regressions:

(1) regressions:

$$PAT_{it}=\alpha+\beta_1*(IRDE)_{it}+\beta_2*(ERDE)_{it}+\beta_3*(PRDF)_{it}+\beta_4*(EWRDD)_{it}+\beta_5*(CRDSS)_{it}+\beta_6*(CRDSR)_{it}+\beta_7*(CRDCL)_{it}+\beta_8*(CRDCO)_{it}+\beta_9*(CRDPR)_{it}+{}^{T}{}_{t}+\delta_{it}$$

(2) regressions:

$$INPROD_{it}=\alpha+\beta_1*(IRDE)_{it}+\beta_2*(ERDE)_{it}+\beta_3*(PRDF)_{it}+\beta_4*(EWRDD)_{it}+\beta_5*(CRDSS)_{it}+\beta_6*(CRDSR)_{it}+\beta_7*(CRDCL)_{it}+\beta_8*(CRDCO)_{it}+\beta_9*(CRDPR)_{it}+{}^{T}{}_{t}+\delta_{it}$$

(3) regressions:

$$INPROC_{it}=\alpha+\beta_1*(IRDE)_{it}+\beta_2*(ERDE)_{it}+\beta_3*(PRDF)_{it}+\beta_4*(EWRDD)_{it}+\beta_5*(CRDSS)_{it}+\beta_6*(CRDSR)_{it}+\beta_7*(CRDCL)_{it}+\beta_8*(CRDCO)_{it}+\beta_9*(CRDPR)_{it}+{}^{T}{}_{t}+\delta_{it}$$

The following are details for the variables in the model of the effects of the innovative effort on the innovative output.

i: firm.

t: year.

a: constant Coefficient.

ß: regression Coefficient.

${}^{T}{}_{t}$: year coefficient.

δ_{it}: error term.

The following explains more:

PAT: Patent. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.

INPROD: Innovative Product. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.

INPROC: Innovative Process. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.

IRDE: Internal R&D Expenses. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.

ERDE: External R&D Expenses. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.

PRDF: Public R&D Funding divided by total R&D costs. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.

EWRDD: Number of Employees Working in the R&D Department about the total number of employees. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.
CRDSS: Collaborates in R&D with Subsidiaries. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.
CRDSR: Collaborates in R&D with Suppliers. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.
CRDCL: Collaborates in R&D with Clients. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.
CRDCO: Collaborates in R&D with Competitors. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.
CRDPR: Collaborates in R&D with Public Research Organizations. takes a value of 1 if it makes internal R&D expenses, 0 if it does not.

Tables 1 and 2 give the descriptive statistics (mean, standard deviation, minimum, and maximum) and correlation matrix for the independent and dependent variables of expression (1) to facilitate the interpretation of the regression output, in addition to analysis of the variance inflation factor (VIF).

Table. 1
Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
1. IRDE	0.4917309	0.4999335	0	1
2. ERDE	0.2292579	0.420357	0	1
3. EWRDD	0.924652	1.2552	0	6.72022
4. PRDF	0.2261543	0.4183414	0	1
5. CRDSS	0.0622783	0.2416611	0	1
6. CRDSR	0.0891954	0.2850263	0	1
7. CRDCL	0.0694217	0.2541707	0	1
8. CRDCO	0.0477803	0.2133016	0	1
9. CRDPR	0.0849334	0.2258031	0	1
10. PAT	0.1044251	0.3058124	0	1
11. INPROC	0.4670695	0.4989162	0	1
12. INPROD	0.4658737	0.4988359	0	1

Table 2 explains the degree of correlation and VIF value among variables:

Table 2.
Correlation matrix and VIF value

Variables	IRDE	ERDE	EWRDD	PRDF	CRDSS	CRDSR	CRDCL	CRDCO	CRDPR	VIF	1/VIF
1. IRDE	1.0000									2.55	0.391616
2. ERDE	0.4090	1.0000								1.38	0.725610
3. WRDD	0.7433	0.4358	1.0000							3.03	0.330035
4. PRDF	0.4868	0.3962	0.5111	1.0000						1.56	0.642048
5. CRDSS	0.1886	0.2343	0.3101	0.1713	1.0000					1.30	0.770084
6. CRDSR	0.2249	0.2480	0.3063	0.2361	0.3674	1.0000				1.47	0.681190
7. CRDCL	0.2593	0.2425	0.3472	0.2825	0.3269	0.4453	1.0000			1.55	0.643927
8.CRDCO	0.2039	0.2027	0.3037	0.2476	0.2289	0.3022	0.3739	1.0000		1.33	0.752370
9. CRDPR	0.3542	0.3949	0.4740	0.4287	0.3739	0.4802	0.5255	0.4623	1.0000	2.02	0.496080

It is clear in Table 2; that the variables do not overlap, repeat, or intersect with another variable. Here, the results of the analysis show that each variable is in its highest possible location compared to other variables. Tables 3. 4. 5. show the effect of the study variables.
Also, table 3 shows the variance inflation factors (VIF) that use a statistical technique to check whether multicollinearity exists between independent variables. However, the results indicate significant relationships between independent variables, and there is not a high correlation between any two variables; none have VIF values of more than 10, The results of the analysis

show that all independent variables have an impact on the dependent variable, as a result of what the analysis revealed. This is consistent with the VIF analysis by entering all study variables and not excluding any variable. This is what researchers interested in studying the topic should do by including all study variables due to their impact on the dependent variable. With the difference in its impact on the dependent variable, the impact of innovative effort, and its impact on patents.

4. Estimation results:

Based on the analysis is derived, and the results obtained from the study are shown. All the estimators are obtained with Stata 14 and are shown in Tables 3. 4. 5. Their columns record the estimates of innovative effort on the innovative output according to geographical areas in Spain.

Table 3.

Explanatory factors for the creation of patents in companies in Spanish regions (dependent variable: PAT).

PAT	All Spain	Madrid	Cataluña	Andalucía	The other regions of Spain
1. IRDE	0.3800141	1.114081	1.045086	0.6709464	0.9146688
	0.000*	0.000*	0.000*	0.091**	0.000*
2. ERDE	0.3800141	0.8676441	0.6590091	0.8733807	0.4798087
	0.000*	0.000*	0.000*	0.001**	0.000*
3. EWRDD	0.4227068	0.5550642	0.6560074	0.5582874	0.6288335
	0.000*	0.000*	0.000*	0.001**	0.000*
4. PRDF	0.3935566	0.6658996	0.6126517	1.036032	0.5373165
	0.000*	0.000*	0.000*	0.000*	0.000*
5. CRDSS	0.073999	0.4185031	0.153986	-0.2824499	0.1826685
	0.197	0.037**	0.368	0.465	0.035**
6. CRDSR	0.203433	0.3199449	0.3208887	0.272112	0.2610054
	0.000*	0.082**	0.040**	0.416	0.000*
7. CRDCL	0.1697431	0.3275991	0.0012499	0.0183104	0.0869128
	0.001**	0.096**	0.994	0.960	0.272
8. CRDCO	0.0215618	0.0631739	-0.3759284	0.1822189	-0.1154268
	0.703	0.761	0.039**	0.559	0.175
9. CRDPR	0.8025997	0.8564442	0.7146241	0.8922265	0.9862143
	0.000*	0.002**	0.001**	0.043**	0.000*
10. Year coefficient	Yes	Yes	Yes	Yes	Yes
11. Obs numbers	125722	13,784	17,359	4,848	72,882

Note: Values with (*), (**), and (***) indicate a significance level of 1%, 5%, and 10% respectively.

Internal R&D expenses have a positive and statistically significant effect on the creation of patents in all regions of Spain. This means that companies that spend more on internal R&D are more likely to create patents. In addition external R&D expenses have a positive and statistically significant effect on the creation of patents in Madrid and Cataluña, but not in Andalucía or the other regions of Spain. This suggests that external R&D is more important for patent creation in some regions of Spain than others.

The number of employees working in R&D relative to the total number of employees has a positive and statistically significant effect on the creation of patents in Andalucía and the other regions of Spain, but not in Madrid or Cataluña. This suggests that having a larger R&D department relative to the size of the company is more important for patent creation in some

regions of Spain than others. Whereas public R&D funding divided by total R&D costs does not have a statistically significant effect on the creation of patents in any region of Spain. This suggests that public R&D funding is not a major driver of patent creation in Spanish companies. Collaborating in R&D with subsidiaries has a positive and statistically significant effect on the creation of patents in Madrid, but not in any other region of Spain. This suggests that collaboration with subsidiaries is more important for patent creation in Madrid-based companies than in companies located in other regions of Spain.
Collaborating in R&D with suppliers has a positive and statistically significant effect on the creation of patents in Madrid, Cataluña, and the other regions of Spain, but not in Andalucía. This suggests that collaboration with suppliers is important for patent creation in most regions of Spain, but not in Andalucía. Collaborating in R&D with clients does not have a statistically significant effect on the creation of patents in any region of Spain. This suggests that collaboration with clients is not a major driver of patent creation in Spanish companies.
Collaborating in R&D with competitors has a negative and statistically significant effect on the creation of patents in Andalucía. This suggests that collaboration with competitors may hinder patent creation in Andalucía companies. However, the effect of collaborating with competitors is not statistically significant in any other region of Spain. In addition, collaborating in R&D with public research organizations has a positive and statistically significant effect on the creation of patents in Cataluña and the other regions of Spain, but not in Madrid or Andalucía. This suggests that collaboration with public research organizations is important for patent creation in some regions of Spain, but not in others.
The coefficient for the year variable is positive and statistically significant, indicating an overall increase in patent creation throughout the study period. Interestingly, the "Other regions of Spain" category has the most observations, while Cataluña has the least.

Table 4.
Explanatory factors of product innovation in companies in Spanish regions (dependent variable: INPROD).

INPROD	All Spain	Madrid	Cataluña	Andalucía	The other regions of Spain
1. IRDE	1.448385	1.66789	1.868679	2.021318	1.577784
	0.000*	0.000*	0.000*	0.000*	0.000*
2. ERDE	0.3163632	0.5339361	0.2836887	0.4120403	0.2489306
	0.000*	0.000*	0.002**	0.023**	0.000*
3. EWRDD	0.2224271	0.2736161	0.3126727	0.1691379	0.2548389
	0.000*	0.000*	0.000*	0.125	0.000*
4. PRDF	0.2363292	0.2497426	0.4423552	0.6234555	0.3852343
	0.000*	0.016**	0.000*	0.000*	0.000*
5. CRDSS	0.7860323	1.350901	1.137826	0.426868	0.9827061
	0.000*	0.000*	0.000*	0.157	0.000*
6. CRDSR	0.622657	1.228358	0.6197651	0.7640081	0.7228079
	0.000*	0.000*	0.000*	0.003**	0.000*
7. CRDCL	0.4580484	0.2793163	0.7180613	1.288179	0.5958357
	0.000*	0.062**	0.000*	0.000*	0.000*
8. CRDCO	0.244709	0.2790486	0.147854	-0.0696715	0.1461033
	0.000*	0.080**	0.359	0.786	0.030**
9. CRDPR	0.7623403	0.8420577	0.7354563	1.219233	0.8711565
	0.000*	0.000*	0.000*	0.000*	0.000*
10. Year coefficient	Yes	Yes	Yes	Yes	Yes
11. Obs numbers	133407	15,239	19,223	5,347	80,565

Note: Values with (*), (**), and (***) indicate a significance level of 1%, 5%, and 10% respectively.

The table shows that companies in Madrid, Cataluña, and Andalucía tend to have higher levels of product innovation than companies in other regions of Spain. This could be due to several factors, including higher levels of internal R&D expenses:
Companies in Madrid, Cataluña, and Andalucía tend to spend more on internal R&D than companies in other regions of Spain. Plus, more collaboration in R&D: Companies in Madrid, Cataluña, and Andalucía are more likely to collaborate in R&D with subsidiaries, suppliers, clients, and public research organizations. The table also shows that the number of employees working in R&D relative to the total number of employees has a positive but statistically insignificant effect on product innovation. This suggests that the quality of R&D employees, as well as the amount of money spent on R&D, may be more important factors than the quantity of R&D employees. Moreover, public R&D funding divided by total R&D costs also has a positive but statistically insignificant effect on product innovation. This suggests that government funding may not be a major driver of product innovation in Spanish companies.

Table 5.
Explanatory factors of process innovation in companies in Spanish regions (dependent variable: INPROC).

INPROC	All Spain	Madrid	Cataluña	Andalucía	The other regions of Spain
1. IRDE	1.086651	1.305987	1.188401	1.327205	1.067924
	0.000*	0.000*	0.000*	0.000*	0.000*
2. ERDE	0.420211	0.7332965	.2238811	0.7203824	0.2960762
	0.000*	0.000*	0.007**	0.000*	0.000*
3. EWRDD	0.0484449	0.0732895	0.0336056	-0.0019489	0.0830306
	0.002**	0.174	0.494	0.985	0.001**
4. PRDF	0.2776912	0.0767459	0.410852	0.8681085	0.4365706
	0.000*	0.422	0.000*	0.000*	0.000*
5. CRDSS	0.7856186	1.368058	0.9287007	0.5951592	0.948341
	0.000*	0.000*	0.000*	0.028**	0.000*
6. CRDSR	1.052683	1.349511	1.187643	1.086613	1.124878
	0.000*	0.000*	0.000*	0.000*	0.000*
7. CRDCL	0.1201016	0.1893518	0.2380751	0.1466935	0.2065304
	0.003**	0.173	0.071	0.581	0.000*
8. CRDCO	0.1348956	0.0790473	-.0416914	0.4879726	0.120846
	0.002**	0.593	0.764	0.048**	0.058***
9. CRDPR	0.5522689	0.5026234	0.5418074	0.8407662	0.6685373
	0.000*	0.010**	0.002**	0.007**	0.000*
10. Year coefficient	Yes	Yes	Yes	Yes	Yes
11. Obs numbers	133406	15,239	19,223	5,347	80,565

Note: Values with (*), (**), and (***) indicate a significance level of 1%, 5%, and 10% respectively.

Internal R&D expenses have a positive and statistically significant effect on innovative process in all regions except "The other regions of Spain". In addition, external R&D expenses have a positive and statistically significant effect on innovative process in all regions. Moreover, the number of employees working in R&D relative to the total number of employees has a positive and statistically significant effect on innovative process in all regions except "Madrid" and

"The other regions of Spain". As well Public R&D funding divided by total R&D costs has a positive and statistically significant effect on innovative process only in the "Cataluña" region. Collaborating in R&D with subsidiaries has a positive and statistically significant effect on innovative process only in the "Cataluña" region. As indicated, collaborating in R&D with clients has a positive and statistically significant effect on innovative process only in the "Andalucía" region. Plus, Collaborating in R&D with competitors has a positive and statistically significant effect on innovative process in all regions except "Madrid". Also, collaborating in R&D with public research organizations has a positive and statistically significant effect on innovative process in all regions except "Cataluña", "Madrid" and "The other regions of Spain".

Companies with more employees working in R&D relative to the total number of employees tend to have higher process innovation. This is statistically significant for Innovative Process, All Spain, and the other regions of Spain. And companies that collaborate in R&D with clients tend to have higher process innovation. This is statistically significant only for Cataluña.

Companies that collaborate in R&D with competitors tend to have higher process innovation. This is statistically significant for all four regions. Moreover, companies that collaborate in R&D with public research organizations tend to have higher process innovation. This is statistically significant for Madrid, Cataluña, and the other regions of Spain.

5. Discussion

The workforce is necessary, particularly in conjunction with an atmosphere that encourages creativity. Organizational rules that encourage establishments to submit their suggestions for job development might help to foster this atmosphere. Innovation is also greatly impacted by research and development expenses, both internal and external. In addition, it's critical to encourage an emphasis on using artificial intelligence. The technological revolution is mostly driven by artificial intelligence, which has an impact on every link in a company's value chain, including employment, human resources, industrial processes, and goods and services. According to some writers, also has the power to drastically alter the structure of R&D and innovation processes, hence altering the essence of innovation itself (Correia & Matos, 2021).

Cooperation with external agents has a statistically significant effect on the innovative output of Spanish companies. This is consistent with Spain's incorporation of the Andalucía innovation strategy into the first Spanish law on science and technology (Ley 13/1986). This law establishes the basis for a national innovation strategy and recognizes the legal capacity and autonomy of the various administrative regions of Spain (a total of 17 autonomous communities) to develop their regional innovations, always in line with European and Spanish innovation policies (Álvarez et al., 2018). In the late 1980s, attention was paid to regional integration and the process of convergence through equal levels of education, homogeneity of productive structures, and technological catch-up in Andalucía, due to the European view that Spanish regions are technologically marginal (Solovieva et al., 2018) .

Public financing has a statistically significant effect on innovative output in Spanish companies. This result is consistent with the European Commission's allocation of the largest part of its budget to the Smart Specialization Strategy (S3) program in 2018. The S3 program supports and identifies the regions' priorities in the necessary innovation and technology sectors through a process of leadership exploration. It also focuses on the concept of regional innovation systems (RIS), which is based on a systematic analysis methodology to investigate the innovation process within regions (Morisson & Doussineau, 2019).

The presence of research and development expenditures means workers are researching to solve administrative problems that impact work in general and create innovative output that has a positive impact on work. Therefore, this study agreed with the study of Schot and Steinmueller (2018), which reached the importance of the expansion of policy instruments

aimed at the formation and mobility of human resources in science and technology and the easy flow of qualified people between universities and corporations.
That explains how companies lost a great chance to develop their work to achieve more market share on local and international levels, although discovering the effect of consultants on innovative process in all study populations, this disagreed with the study of Aguirre Campoverde, et al., (2021) which showed that companies are aware of engaging sources in innovative processes to achieve goals through innovation.
There is a statistically significant effect of external factors on the innovation output of Spanish companies, therefore this study agreed with Miguelez and Moreno (2018), who provide evidence that external factors positively affect innovation output, plus the role of research and development in stimulating innovation and applying new ideas to the formation of new sectors.

6. Conclusions and policy implications:

Our study makes the following primary contributions:
We utilized a rich panel dataset, the PITEC, encompassing 12,849 Spanish companies across all sectors from 2003 to 2016. This database provided observations from diverse sources over an extended timeframe. In contrast to the majority of innovation studies that rely on cross-sectional data, time series data, or short-term panel data with limited samples, we employed a comprehensive panel dataset spanning a longer period. This approach allowed us to capture the dynamic relationships between the exploratory variables. Consequently, the logit model for panel data emerged as the most appropriate statistical methodology for our analysis.
Innovation is a complex and systemic process with many factors, and environmental differences affect it as a core element. This is why there is much debate among authors about the evidence or contradiction of indicators, and why innovation in one area is not necessarily a success in others, and very important studying the phenomena as a whole does not make detailed.
Innovation effort is an integrated process based on the combination of internal and external factors. It is the product of many factors that influence it, beginning with general culture and ending with geographical area, taking into account research and development, as well as scientific knowledge and intellectual capital, as well as consensus at the state level in taking appropriate steps to make effective efforts to achieve innovative processes in different regions that affect the expansion of existing knowledge to those working in this area and to learn about different experiences through coordination with public or private research and training centers, with emphasis on the participation of the formulation of innovation policies by all social groups at the state or regional level.
Research and development (R&D) is essential for creating an atmosphere that fosters innovation. Productivity growth can be attributed in large part to research and development. Increased productivity can also be considered a catalyst for innovation, as it can occasionally result in shorter production times. Research and development (R&D) is a key component that is necessary to achieve successful innovative solutions.
External factors have a statistically significant impact on the innovation output of Spanish companies, demonstrating the positive impact of external factors on innovation output and the importance of research and development in fostering innovation and utilizing new ideas to form new sectors.
This is consistent with the VIF analysis by entering all study variables and not excluding any variable. This is what researchers interested in studying the topic should do by including all study variables due to their impact on the dependent variable. With the difference in its impact on the dependent variable. The overall impact on Spain as a whole was positive. Andalucía and Cataluña should work to promote patents by opening up cooperation with different research

institutions and building institutions that support individuals who provide innovative services in the industrial or service sector.

It is very important to create a culture that confirms and promotes innovative effort depending on time and understanding of the potential for action and twins to produce innovative output. Also taking appropriate steps at the state level to make effective efforts to achieve innovative processes in different regions that affect the expansion of existing knowledge to those working in this area and to learn about different experiences through coordination with public or private research and training centers, with emphasis on the participation of the formulation of innovation policies by all social groups at the State or regional level.

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Annex 1.
The field of industry companies.

Agriculture	Coking firm, Oil refining coking firm	Machinery and Mechanical equipment	Furniture	Hostelry	Investigation and development
Extractive	Chemicals (except pharmaceutical products)	Office machines and computer equipment	Games and toys	Transport	Architecture and engineering technical services
Food and drink	Pharmaceutical products	Machinery and electrical equipment	Other manufacturing	Activities related to transportation travel agencies	Technical tests and analysis
Tobacco	Rubber and plastic materials	Electronic component	Recycling	Postal and courier activities	Other business activities
Textile	Tiles and ceramic tile	Radio and communication devices	Production and distribution of electricity, gas, and water	Telecommunication services	Education
Garment and fur	Non-metallic mineral products (except tiles and ceramic tiles)	Medical and Precision instruments, optical	Construction	Financial intermediation	Film and video activities
Leather and footwear	Ferrous metallurgical products	Motor vehicles	Sale and repair of motor vehicles	Real-estate activities	Radio television activities
Work and cork	Non-ferrous metal products	Naval building	Wholesale trade	Machinery and equipment rental	Other health social and collective activities
Paper	Metallic products (except machinery and equipment)	Aeronautical and construction	Retail Trade	Software	Investigation and development
Editing, Graphic arts, and reproduction	Coking farm, oil refining	Other transport equipment	Furniture	Other computer activities	Architecture and engineering technical services

Source: own calculations from PITEC.