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Collaborative R&D and technology transfer: a rapid and effective route to the success of innovation?

A system-oriented assessment for Portugal 2020's Demonstrator projects

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I dedicate this work to my parents, Maria João and José, for the unconditional love.

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ABSTRACT

Technology transfer - defined as the reciprocal movement of *know-how* between an institutional technological environment and an industrial environment - has operated as an enabler of the business innovation process. Its socio-economic benefits have warranted the interest of organizations, since it allows them to acquire a larger set of *skills*, to complement their learning and to more rapidly overcome any obstacles that might arise in technology development and commercialization.

In this regard, within the 2014-2020 Framework, *policy-makers* reinforced their innovation support programmes and policies, for the purpose of stimulating this phenomenon and thereby foster a structural transformation based on competitiveness and economy specialization in multiple and interconnected spaces. Nevertheless, a holistic assessment of those instruments, which might foster coherent and transparent decision-making in Portugal, is plainly lacking.

In the light of this, the current dissertation puts forwards a systemic assessment methodology and applies it to one of the measures that promotes technology transfer – the *Demonstrator projects*. This assessment model makes it possible to monitor, inform and disclose the efficiency with which the activities are coordinated, the quality of the processes, the prospective effects and externalities, as well as their market potential, in an accurate and comprehensive way.

The results were quite clear: innovation, by means of technology transfer, promotes more qualified employment, dissemination actions, desire for business expansion, international connections, interregional and intersectoral collaboration and, consequently, technologies with larger innovative and commercial capacity. Emphasis is therefore put on fostering its practice in Portugal, which entails the concertation of the existing deficit between all the economic agents comprising it.

Keywords: Technology transfer; Innovation support instruments; Assessment methodology; Demonstrator Projects.

JEL Codes: 022, 032, 038.

RESUMO

A transferência tecnológica - caraterizada como o movimento recíproco de *know-how* entre um ambiente institucional tecnológico e um ambiente industrial - tem atuado como facilitadora do processo de inovação empresarial. Os seus benefícios socioeconómicos têm despertado o interesse das organizações, uma vez que lhes permite adquirir uma maior base de *skills*, complementar aprendizagens e mais rapidamente superar quaisquer obstáculos com que se deparem no desenvolvimento e comercialização tecnológica.

Neste contexto, no Quadro 2014-2020, os *policy-makers* reforçaram os seus programas e instrumentos de apoio à inovação, visando estimular este fenómeno e, assim, fomentar uma transformação estrutural baseada na competitividade e na especialização da economia em espaços múltiplos e interligados. Todavia, denota-se a ausência de uma avaliação holística desses instrumentos, com vista a tomadas de decisão coerentes e transparentes em Portugal.

Face a esta evidência, a presente dissertação propõe uma metodologia de avaliação sistémica e aplica-a a uma das medidas que promove a transferência tecnológica - *os projetos Demonstradores*. Este modelo permite monitorizar, informar e divulgar sobre a eficiência com que as atividades são coordenadas, a qualidade dos processos, os possíveis efeitos e externalidades, bem como o seu potencial de mercado, de forma precisa e abrangente.

Os resultados foram bastante claros: a inovação, através da transferência tecnológica, promove mais emprego qualificado, ações de difusão, vontade de expansão de negócio, ligações internacionais, colaboração intersectorial e interregional e, por conseguinte, tecnologias com maior capacidade inovadora e comercial. Enfatiza-se, assim, um maior estímulo à sua prática em Portugal, o que implica a concertação do défice existente entre todos os agentes económicos seus constituintes.

Palavras-chave: Transferência de tecnologia; Instrumentos de apoio à inovação; Metodologia de avaliação; Projetos Demonstradores.

JEL Codes: 022, 032, 038.

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LIST OF ACRONYMS

ANI	National Innovation Agency
CSF	Common Strategic Framework
DG CONNECT	Directorate-General for Communications Networks, Content and Technology
EC	European Commission
EEC	European Economic Community
ENEI	Innovation Strategy for Smart Specialization on a National Level
EREI	Innovation Strategy for Smart Specialization on a Regional Level
EU	European Union
GVA	Gross Value Added
IAI	Innovator's Ability Indicator
IAPMEI	Portuguese Agency for Small and Medium Enterprises and Innovation
IBM SPSS	International Business Machines - Statistical Package for Social Sciences
ICI	Innovator Capacity Indicator
IEI	Innovator's Environment Indicator
IMI	Innovation Management Indicator
IPR	Intellectual Property Registration
IPI	Innovation Potential Indicator
IR	Innovation Radar
IRI	Innovation Readiness Indicator
ISCED	International Standard Classification of Education
JRC	Joint Research Centre
MPI	Market Potential Indicator
NIS	National Innovation System
NSRF	National Strategic Reference Framework
NUTS	Nomenclature of Territorial Unites
OECD	Organization for Economic Cooperation and Development
PT2020	Portugal 2020
R&D	Research and Development
SI R&D	Incentive System for Research and Development
SIFIDE	Tax Incentive for Company Investments in Research and Development
SMEs	Small and Medium Enterprises
UNESCO	United Nations Educational, Scientific and Cultural Organization

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CHAPTER 1
INTRODUCTION

The importance of innovation for economic growth and competitiveness resulted in gradual attention being given to the effective links existing between the business world and technology infrastructures (Carayol, 2003; Cunningham, 2007; Cunningham *et al.*, 2017). These links have enabled traditional organizations to attain a larger set of *skills*, to gather specialized technical competencies and to complement their *expertise* in order to more easily and rapidly overcome any obstacles which might arise throughout the innovation process, whether they are financial, technological or commercial (Zuniga and Correa, 2013; Fagerberg *et al*., 2014). One of these main effective links is **technology transfer**, defined as the movement of *know-how* and scientific discoveries between an institutional setting of a prominently technological nature and an organizational/industrial environment (Roessner, 2000; Bercovitz and Feldman, 2006).

Technology transfer has operated as an enabler and promoter of the entire business innovation process, by means of various channels (both formal and informal). Nowadays, these liaisons take on special significance, since organizations face growing competition, an ever-escalating pace of innovation and a shorter life cycle. They're thus led to seek new business strategies in addition to quicker and more sophisticated ways of innovating (Amesse and Cohendet, 2001; Scandura, 2016; Gault, 2018).

The social and economic benefits of technology transfer have warranted the interest of *policy-makers* in planning, designing and implementing policy instruments that stimulate and support its occurrence (Schot and Steinmueller, 2018). Accordingly, the European Union (EU) research and innovation policy of the last few years (*Innovation Union* and *Horizon 2020*) has promoted an ongoing relationship between science, technology and innovation in economy, fostering, in addition, the constant collaboration between the companies which strive to innovate and the entities that promote knowledge (Bozeman, 2000; EU, 2013, 2014; Szucs, 2018).

With the purpose of tackling R&D (Research and Development) shortcomings and deficiencies and make the economy more competitive and innovative, Portugal has been no exception in the last few decades. Its *core* strategy has involved promoting innovation in the economy as a crucial vehicle for the increase of productivity and efficiency in national companies, through the incorporation of new technologies in production processes, according to the targets of the current Support Framework – *Common Strategy Framework (CSF)*: *Portugal 2020* (EU, 2014).

The execution of these plans has demanded an extended effort (both direct and indirect) regarding support initiatives. However, the monitoring and assessment of such processes require improvement, in order to make it possible to evaluate with more precision and robustness the externalities of multidisciplinary collaboration, in force in a great portion of the current innovation processes.

In view of this scenario, the current thesis focuses particularly on the phenomenon of collaborative R&D and the technology transfer process which it implicates. Following a line of reasoning that moves from the general to the particular, this research aims to understand diachronically the main tendencies and theoretical influences in these fields, by means of a thorough review of the existing economic and empirical literature.

With this essentially positive contribution, the goal is to provide the necessary background so as to question, with thoroughness and expertise, the origin of the *Incentives System for Research and Development* (SI R&D) assessment. The financial instrument which enabled a complete assessment of the phenomena under analysis is the *Demonstrator Projects* instrument, composed of *two different typologies*: *(i)* ***individual*** **projects**, developed by a single national company, and *(ii)* ***co-promotion*** **projects**, developed by collaborative *networks* between the multiple actors of the innovation system. This instrument therefore operates, in this study, as a *proxy* to these phenomena.

Given the complexity of the new innovation model's support measures, this thesis ***puts forwards a new assessment methodology oriented towards an integrated and systemic approach, which follows up on the entire innovation process and monitors all its internal and external constraints***.

The execution of this assessment methodology is primarily based on a *new merit referential,* which is to be administered to the Demonstrator projects' applications proposals. Its construction was grounded on the empirical and theoretical principles of economic literature and was guided by *Portugal 2020*'s priority goals. Its implementation entailed the coordinated participation of specialists proficient in current market dynamics and *experts* in the multiple scientific domains which underlie the development of these innovations.

At a final stage, the main obtained results were assessed, particularly the potential of the developed innovations and the effectiveness of the promoters in taking them to the market. For this purpose, the most recent assessment tool of R&D instruments, which was designed by the European Commission (EC), was applied: *Innovation Radar* (IR). This tool covers the dynamic initiatives that the current innovation process entails, thereby demanding direct contact with them.

IR is relevant in its attempt to develop, refine and update the assessment method of innovation support policies. By means of a methodology that is based on epistemological constructivist techniques, it is possible to integrate objective and subjective assessment criteria, to assign considerations to these criteria according to their importance with regards to public policy priorities and to assess collaborative R&D and technology transfer's efficiency and effectiveness in the development of innovations.

It is worth noting that even though the topic of innovation is nowadays recurrently studied, assessments of policy programmes and instruments are still scarce within this field (Cunningham *et al.*, 2017; Schot and Steinmueller, 2018), particularly in Portugal. Although the concept of innovation system was first introduced in the decade of 1990 and was applied in the design of instruments in the decade of 2000, its assessment, oriented towards a systemic and interactive approach, is not yet rationalized.

In view of this, the current thesis represents an opportunity for progress in this direction, through a holistic assessment, more concise and realistic, which will make it possible to reach an unequivocally more enlightened and informed decision, regarding the potential of the current measures and innovations.

In order to accomplish its goals, this dissertation is divided into *five parts*. The first is a literature review of the topics under analysis (*chapter II*), the second analyzes the SI R&D current governance model and the corresponding financial instrument under consideration (*chapter III*), the third focuses on the research methodology (*chapter IV*), the fourth presents the results of its application (*chapter V*), and, at last, the main conclusions are set forth, as well as their implications for public economy and policy, besides making suggestions for future research.

In short, the purpose of this study is not only to develop a positive analysis but also to draw conclusions for a normative analysis of this interdisciplinary field.

CHAPTER 2
LITERATURE REVIEW

This chapter is centered around the basic concepts of this research. It is divided into three subchapters which are closely connected. Firstly, it focuses on the concepts of science and technology, since these are considered by many economists to be the elementary concepts of the topic of innovation. This is followed by an overview of the rise of innovation studies and their contribution to economy, which considers this process through the filters of two predominant perspectives in economics of innovation - neoclassical and evolutionary.

Subsequently, technology transfer will be highlighted, with the emphasis being laid on its role, importance and impact on the process of innovation. The phenomenon will be thoroughly conceptualized and the most common situations in which it takes place will be put forward. The mechanisms underlying its operation, the *key-actors* and their corresponding functions, as well as the benefits of this paradigm to the process of innovation and technology commercialization will also be under consideration.

Finally, attention will be brought to the evolution of the situation of community and national policy, regarding the field of research and innovation, within the current Framework Programmes and initiatives. Additionally, the progress in the design of policy measures and instruments which are directed towards the systemic approach in Portugal will be underlined, through the analysis of the specific objects and goals, as well as of the support provided by management and coordination entities of the current investment support programmes for business R&D and innovation.

The aspects addressed in this chapter function as the theoretical and empirical foundation for the methodology and ensuing data analysis that are to be conducted in *chapters 4* and *5* of the current dissertation.

2.1. Science, technology and innovation in economic literature

2.1.1. From scientific and technological discovery to innovation

The never-ending quest for better material living conditions has entailed a continuous boost in cognitive development, which has been accompanied by an attempt to adjust it to the operating mode of the material sphere (Caraça, 2003). In this context, the emergence of modern science in seventeenth-century Europe takes place within the framework of social and economic activity, escalating throughout the period of development that followed the transformations brought about by the ***industrial revolution*** (Freeman, 1987). Science, which plays an essential role in modern societies, thus owes its existence and development to the endeavors of individuals and new institutions, as well as to the reciprocity of their interactions (Martin, 2016; McNie *et al.,* 2016).

Throughout the centuries, ***science and technology*** have come to be considered fundamental elements in defining development strategies and creating long-term opportunities. In parallel with this growing awareness, the twentieth-century witnessed a considerable expansion of the *stock* of scientific knowledge (Freeman and Perez, 1988). The applicability of science has increased and the scientific foundations of technological development processes have been greatly reinforced (Small *et al*., 2014). Accordingly, *The United Nations Educational, Scientific and Cultural Organization* (UNESCO) (1979) has defined scientific and technological activities as systematic activities concerned with the creation, advancement, dissemination and application of scientific and technical knowledge in all fields of expertise.

It should be noted that, although it is not possible to completely dissociate science from technology with respect to R&D processes, these concepts may be considered separately regarding their corresponding purposes (Martin, 2016). Whereas ***science*** is described as an organized stock of knowledge about the causal mechanisms of observable facts, attained through an objective study of empirical phenomena, ***technology*** is the stock of scientific or empirical knowledge directly applicable to the production, improvement and use of goods and services (UNESCO, 1979). Furthermore, technology also displays the *entrepreneurial expertise* and necessary *know-how* in order to deliver a product, process, method or innovative service (Small *et al*., 2014).

Presently, science and technology are the driving forces behind new processes and technical artifacts, both from the perspective of innovation and research policies and from the company and entrepreneur's vantage point (Gault, 2018). That being said, ***R&D activities*** are a relevant part of a broader notion – ***innovation*** –, concerning necessarily the set of basic *inputs* of that interdisciplinary concept, together with demonstration actions and other scientific and technological activities (McNie *et al.,* 2016). Given its importance over the years, the concept of innovation has been studied by several authors who highlight its complexity, both in the public and private sectors, demonstrating its pervasiveness and clear dynamism (Steinmueller, 2017).

In order to demystify this multidisciplinary concept, it is important to stress that academic and corporate interest in innovation has intensified since the mid-1970s, when it became evident that significant changes were required in the production system and organizational configurations. In this context, innovation has become an essential precondition to achieve success, chiefly due to the need of adapting organizations to increasingly unstable, unpredictable and dynamic environments (Kovács *et al.,* 2015).

In economic literature, the concept of innovation was initially associated with *technological change*, shifting over time with the different theoretical approaches. Up until the 1950s, *technical progress* (*i.e.*, equipment improvements) was used as a synonym of ***process innovation***, which was asserting itself as a solution for cost, productivity, employment and competitiveness concerns. However, years later, with the impulse given by Austrian economist Schumpeter and through the adoption of a long-term perspective, the notion of ***product innovation*** arises as a factor of great economic relevance (Schumpeter, 1950, 1982; Utterback, 1994).

Nowadays there are a significant number of more accurate and sophisticated possible definitions. The most common one ascertains that innovation occurs when an invention reaches the market, attesting to Schumpeter's timeless intellectual legacy (Dervitsiotis, 2010). This definition allows for a clear distinction between the concepts of invention and innovation as *two different consecutive stages* (Freeman, 1987; Caraça, 2003). Whereas ***invention*** consists of a prolific idea or scheme which "enters" economy or an anticipation of the possibility of a new product, process or system (*i.e.*, usually the result of R&D activities), ***innovation*** corresponds, in turn, to the fruitful transformation of invention, achieved through the creative activity of an "entrepreneur". It is the first commercialization of a new product, process or system (Geroski, 1990; Godinho, 2013; Fagerberg *et al*., 2014). Nonetheless, innovation only acquires economic significance by means of a *third fundamental stage* – ***diffusion*** - which refers to the rapid and broad dissemination of innovations among the population of potential users (Fuentelsaz *et al.,* 2016).

According to the *schumpeterian approach*, innovation is thus connected to historical and irreversible change in the way things are done (Schumpeter, 1950). It states, therefore, that technical change leads to economic growth through a process of 'creative destruction'[1], with novelty leading to short-term disruption and long-term transformations in economic structures (Schumpeter, 1950, 1982). Schumpeter thus suggests a ***classification of innovation*** according to its ***nature*** (*i.e.,* existing types of innovation) and according to its ***class*** (*i.e.,* economic impact of the innovation), which is still used today in empirical studies (*Figure 1*).

Figure 1: Classification of innovation activities

Nature of the innovation
Introduction of a new product or qualitative modification of an existing product Introduction of a new method of production or improvement of an already existing process Opening of a new market Acquiring new sources of supply for *inputs* Changes in the organizational structure (*e.g.,* monopoly position)
Class of innovation
Incremental or gradual innovations (*i.e.,* usually associated with improvements in products or services) Radical innovations (*i.e.,* usually discontinuous, they result in the replacement of an old product/technology by a new one) Changes in the technological system (*i.e.,* profound changes in technology which affect multiple economy branches or promote new complementary sectors) Changes of techno-economic paradigm (*i.e.,* technological revolutions which globally affect the entire economic system)

Source: Own design, based on Fagerberg *et al.* (2014).

In the 1990s and 2000s, some aspects of Schumpeter's ideas regarding innovation were revived, sparking a debate within economic theory and controversy among economy's *mainstream.* This resulted in new theoretical developments about innovation and the rise of a new area of expertise – ***innovation economy*** (Guellec, 1999). Against this background, new theories pertaining to the ideas of *networks* and *systems* emerge and emphasize the unpredictability and interactions (Steinmueller, 2017). The theory of the ***national innovation systems***[2] (NIS) offers a new perspective on this issue, by arguing that technical change stems from learning and cooperation processes between companies and other institutions, which regard innovation in an integrated way (Lundvall, 1992; Binz and Truffer, 2017).

In a business environment, innovation works as a driving force which propels companies towards more ambitious, long-term goals, handles the renewal of industrial structures and is responsible for the rise of new sectors of economic activity

[1] As stated by Schumpeter (1982), there is a process of *creative destruction* associated with the innovation phenomenon, to the extent that innovation generates profits for the innovator but decreases the profit of non-innovators.
[2] The contributions of the NIS become evident when compared to economy's *mainstream*. In the traditional approach, a static view of technique is predominant. According to this perspective, technique is a good or product that companies purchase from the market (Binz and Truffer, 2017).

(Giannopoulou *et al.,* 2018; Gault, 2018). The ***companies' motivation to innovate*** comes to be considered ***intrinsic*** - and to be associated, for instance, with survival and competitiveness strategies – and/or ***extrinsic*** – in which case, a number of factors that foster innovation are at play, in the political, economic, social, technological and legal spheres (Kovács, 2000; Borrás, 2011; Kovács *et al.,* 2015).

Given its evolution as a concept and the way it is understood, innovation is considered to be a cumulative and interactive process of learning and continuous improvement, which exceeds the formal boundaries of R&D. Moreover, it does not rest solely on the technological component, but also on other constituents, such as the organizational aspects and marketing itself. On this account, companies belonging to sectors in which research is an important source of innovation, engage in global R&D *outsourcing*, increasingly abandoning an isolated role of corporate R&D, in favor of R&D partnerships, collaborations and subcontracts at a global level (Schot and Steinmueller, 2018). For this reason, an intraorganizational and interorganizational learning culture - directed towards the results of the ***innovation process*** – is increasingly required (Lundvall and Borrás, 1998; Kovács *et al.,* 2015).

2.1.2. The innovation process

Between the mid-twentieth century and our current days, *two prevailing trends* are recognizable in scientific debate regarding the characteristics of the innovation process and the factors which might prompt or constrain it. The approach to the relative importance of *market* and *science* thrived at an early stage, whereas the systemic approach to innovation and *innovation networks* has risen more recently, weighing in the importance of other factors which interfere with this process. It is thus possible to split these theories on innovation into *two categories*: *(i)* ***historical approaches*** and *(ii)* ***current approaches to innovation***.

2.1.2.1. Historical approaches to innovation

According to Schumpeter's perspectives, there are two distinct, albeit complementary, phases in the approach to innovation. In *Theory of Economic Development*, published in 1912, the author specifically emphasizes the individual action of the innovative entrepreneur, who is referred to as the entrepreneurial individual, capable of introducing new combinations of available (human and material) resources, shaped as new products or organizational methods (*i.e.*, alluding to the entrepreneur as the agent of *creative destruction*) (Schumpeter, 1950). Thirty years later, in his book *Capitalism, Socialism and Democracy*, Schumpeter continues to assign the role of innovator to the entrepreneur. However, this time round, the individual entrepreneur is replaced by the collective entrepreneur, in the role of protagonist of the innovation process. Hence, he considers that large companies display internal skills for R&D and are capable of producing technological innovations. In parallel, he breaks with neoclassical perspectives, by regarding innovation as an endogenous factor to organization itself, acknowledging the roles of *market* and *science* and the monopoly's tendency towards the production of technological advancements (Schumpeter, 1982).

On that account, the ***technology-push*** or ***science and technology push*** approach is centered around the idea that innovation is propelled by scientific breakthroughs and is based on scientific and technological knowledge. The innovation process therefore unfolds in a sequence of consecutive stages, from primary scientific activities to the introduction of new products into the market. It stands on *two fundamental premises*: that *(i)* a company endowed with a good research team more easily recognizes the possibilities provided by scientific knowledge and manages to turn them into potential commercial applications, and that *(ii)* innovative activity is highly dependent on the company's *stock* of knowledge. More R&D thus translates into more innovative results (Horbach *et al.*, 2012).

In following a different line of reasoning, supporters of the ***market-pull*** or ***demand-pull innovation*** approach argue that technological progress is restrained by economic and social factors and that the rise of technological innovations is boosted primarily by market opportunities. It is therefore the demand curve that stimulates innovation (Nemet, 2009; Brem and Voigt, 2009; Horbach *et al.*, 2012).

In view of the foregoing, innovation is initially understood as a ***linear model*** which directly stems from a short and sequential chain of stages, with R&D necessarily culminating in marketable inventions (Organization for Economic Cooperation and Development (OECD), 2005; Cooper, 2007) (*Figure 2*).

Figure 2: The conventional linear model of innovation

Research → ***Development*** → ***Production*** → ***Marketing*** → ***Use***

Source: Own design, based on OECD (2005).

However, it should be emphasized that this perspective, which for a long time dominated the debate about technological change, has been subjected to intense criticism in the academic world for the last few decades, particularly owing to flaws and shortcomings in the explanation of the innovation process (Lundvall, 1992). Among these, the most relevant are: *(i)* the exceeding importance given to R&D, accompanied by the neglect of other innovation factors; *(ii)* the arbitrary dissection of the different stages, since the process is progressive and continuous; *(iii)* the idea of the economic system as passive and reactive and not as a useful source of creativity in itself; *(iv)* the absence of *feedback loops* between the different stages in the innovation process and between the actors – unidirectional model; and *(v)* rationalizing difficulty and discarding genuine uncertainty, even though it is acknowledged today that the *trial and error* method is crucial in this procedure (Shenhar, 2001; Kok and Biemans, 2009).

These theoretical deficiencies, as well as the need to assess the impact of large public R&D investments in the post-war period, lead to the development of other models which seek to present the interactive nature of the process. Bearing in mind the limitations of the linear model, Kline and Rosenberg (1986) introduce an improved model, entitled ***chain-linked model***, which describes innovation through processes of interactive learning that occur predominantly within the borders of an organization (*e.g.,* R&D department). The learning process can be established between *the organization* and both *upstream* (*e.g*., suppliers of goods, services and technologies) and *downstream* (*e.g.,* marketing and distribution, industrial clients or *end-users*) activities. This model combines two types of interaction, namely the internal processes of the organization (or *network organizations*), and the relationships between an organization and the global system of science and technology.

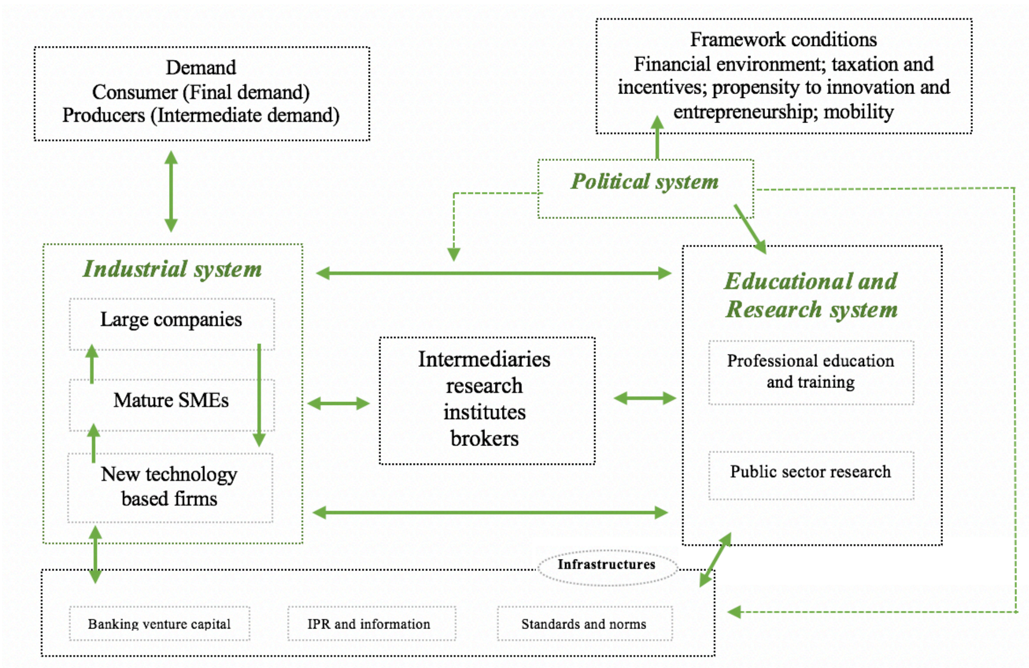
2.1.2.2. Systemic approach to innovation

The systemic approach to innovation was developed in the mid-1980s and it has enriched innovation analysis by adding in new factors, such as the culture or the history of the countries and regions where innovation occurs and spreads (Chesbrough, 2003, 2006). As such, with science being increasingly supported and constrained in accordance with economic purposes, technological innovation stops being conceived as a mere clash between the market's necessities and the technological opportunities generated by the scientific system (Edquist, 1997; Dahlander and Gann, 2010; Binz and Truffer, 2017).

Against this background, an economy's capacity to innovate comes to depend on its corresponding NIS, as well as on all the environmental factors affecting it and the degree of interaction between the different components of the system (Lundvall, 1992; Caraça, 2003). Therefore, this broader perspective considers not only all the immediate ingredients that take part in the confection of innovation, but also all the factors which have an impact or affect each particular process of innovation (Lee *et al.*, 2010; Chesbrough and Bogers, 2014; Santos, 2016).

There are hence *two main implications*: *(i)* the innovation process is mostly cooperative between companies, between companies and their clients, between companies and their financiers, between companies and universities or between companies and the government, making the necessary coordination between science and innovation a crucial aspect to keep in mind; and the awareness that, *(ii)* the effectiveness of the innovation processes depends on the situation of the institutions that affect the behavior of the economic agents (West *et al.*, 2014). Given its current relevance, *figure 3* provides a generic outline of a NIS, created by the OECD (2005).

Figure 3: A generic national innovation system



Source: Own design, based on OECD (2005).

Regarding this systemic approach, it is important to highlight the existence of ***effective links*** which allow the organizations to access a larger *stock* of ideas and technologies, to find complementary intellectual knowledge and gather *skills*, which will enable them to overcome any economic, social or technological obstacle (Zuniga and Correa, 2013; Binz and Truffer, 2017). Currently, these links are particularly important, given the fruitful competition between organizations, leading them to systematically search for new business strategies, as well as for quicker and more sophisticated ways of innovating (Scandura, 2016).

The new innovation practices carried out in technology-based companies' function, therefore, as a permeable system with multiple connections to external actors. As such, the transfer and flow of knowledge between companies and the exterior and the use of business models in the commercialization process, as well as in expanding the companies' innovation capacity, are imperative (Bhupatiraju *et al.,* 2012)

The process exhibits, today, characteristics that could hardly be normalized, considering that *(i)* innovation is less and less about acquiring technical knowledge, demanding, on the other hand, the combination of knowledge on different market sectors or segments (Schot and Steinmueller, 2018); *(ii)* the costs and the economic significance of technological innovation have substantially increased, which entails more financial capacity, more division of labor throughout the process and, consequently, an increase of the importance of cooperation as a learning and risk-sharing mechanism (Arundel *et al.,* 2019); and, *(iii)* in the sectors in which innovation is more straightly connected with scientific research (*e.g.,* pharmaceutical, biotechnology or robotics), more attention is given to the protection system of commercial exploitation rights, which are crucial in order to stimulate innovation (Geuna and Rossi, 2011; Vásquez-Urriago *et al.,* 2016).

2.2. Technology transfer in economic literature

2.2.1. The phenomenon and its performance context

The importance of innovation for medium to long-term economic growth has resulted in gradual attention being given to the process of transferring ideas, knowledge and technologies from lab to market (Krugman, 1978), as initially it was considered that researchers were the main information source that drove technology (*i.e.,* innovation) directly to the market (Allen, 1977).

A few years later, Bozeman (2000) put forward a model which regards the technology transfer phenomenon as a process of transactions through which questions, clarifications, answers and other pieces of information flow both ways and depend upon the interaction between different agents throughout the entire process.

Given its scientific and economic relevance, this phenomenon has received special attention from multiple researchers and *policy-makers*, mainly due to the progress in studies concerning innovation and to the acceptance of the collaboration and *network logic* as the most ingenious and efficient way to reach an integrated knowledge economy (Bercovitz and Feldman, 2006).

In this respect, technology transfer, coupled with the interactive and systemic vision of the innovation process, has escalated and expanded in the last few decades, particularly owing to the following *four interconnected factors*: *(i)* the development of new technology platforms, *(ii)* the growing scientific and technical content of all types of industrial production, *(iii)* the increasing demand for new funding sources of scientific and technological research, targeted at the existence of the *science-company* consortium, and *(iv)* the prominence of policy measures and instruments aimed at boosting the economic return of the technological research that was conducted (Newman *et al.,* 2015; Cunningham *et al.,* 2017).

Specifically, in macroeconomic terms, a number of authors argue that the existence of technology transfer clearly promotes economic, social and territorial development, national and regional competitiveness, entrepreneurship, and national technological potential, as well as growth and the creation of qualified jobs (Bozeman, 2000; Blalock and Gertler, 2008). From a microeconomic perspective, this phenomenon seems to influence the performance of the organizations, particularly by increasing their productivity, the efficiency of their R&D and innovation processes, their absorptive capacity and even the social and economic valuation of the scientific knowledge that was generated (Carayol, 2003; Hu *et al.,* 2006).

Roessner (2000, p.1) devotes himself to this phenomenon specifically in his empirical endeavors and describes it as "the physical movement of artifacts or immaterial elements, such as *know-how* and technical knowledge or, more frequently, a specific set of *skills*, between two or more people, groups or organizations, both public and private". Other empirical studies from the 2000s show that establishing *links* with outside entities - namely technology infrastructures – is a *key* component in business strategy, since it enables the exploitation of the applied research (Amesse and Cohendet (2001), and the access to different albeit complementary knowledge, from the technological portfolio which exists in organizations (Bercovitz and Feldman, 2006).

More recently, McNie *et al.* (2016) has defined this phenomenon as the transfer of assets from the technological and scientific system to companies and/or government institutions, regarding it as a stimulator of economic value and industrial development and as an enabler of the commercial use of the designed innovations. Giannopoulou *et al.* (2018) adds that transfer encompasses the identification of new technologies, their protection by means of patents, *trademarks* or author rights and the formulation of development and commercialization strategies (*e.g.,* marketing and licensing) existing companies in the private sector and/or the creation of new technology-based *start-ups*.

With regard to its performance environment, traditional economic literature identifies *four broad performance situations*, concerning technology transfer. The contexts can be split into ***internal*** (*i.e.,* inside an organization) or ***external*** (*i.e.,* between organizations); in addition, technology transfer may occur in the ***innovation process*** (*i.e.,* the creation of technology) or the ***dissemination process*** (*i.e.*, technology reproduction) (Amesse and Cohendet, 2001). These are all featured in *figure 4*.

Figure 4: Types of technology transfer contexts

	Within organization	***Between organizations***
Creating technology	***Situation I*** Managing innovation	***Situation II*** Contracting out R&D and outsourcing
Reproducing and diffusing technology	***Situation III*** Transferring to divisions or subsidiaries	***Situation IV*** Buying or selling proven technologies

Source: Own design, adapted from Amesse and Cohendet (2001).

In view of the above, it is possible to ascertain that technology transfer has important benefits on the companies' organizational performance and on the economic and social performance of the countries which employ it. These benefits are incorporated in knowledge spillovers and are attained by means of technological cooperation. Overall, by drawing on the process of knowledge transfer, countries promote innovation and, by doing so, increase industrial productivity, create more and better job opportunities and more easily tackle the challenges brought about by strong competition and market globalization (Newman *et al.,* 2015).

2.2.2. Mechanisms, transactions and *key-actors*

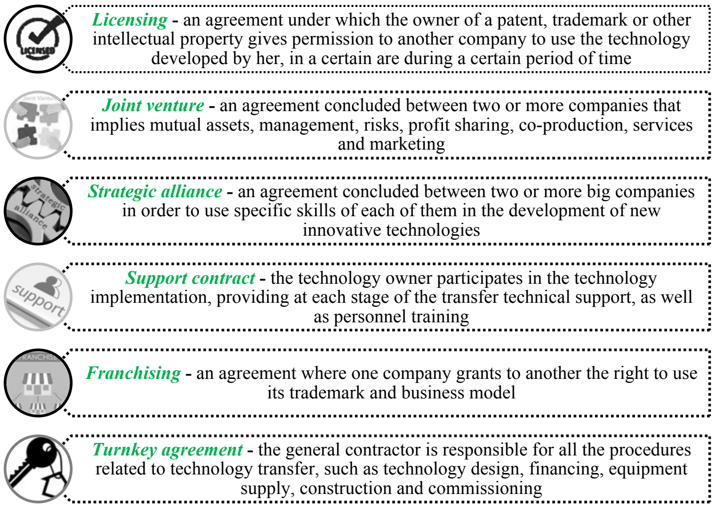
Technology transfer is becoming an increasingly broad phenomenon, which encompasses a vast array of strategic interactions. It is embodied in collaborations, including research partnerships, contract research, research consortia, consulting and funding of cooperative research centers, through the sharing of their knowledge and *skills*, as well as of their personnel and R&D facilities (Perkmann *et al.,* 2013).

Technology commercialization comprises different kinds of ***transactions between research entities and companies***, which may occur sequentially and simultaneously so as to strengthen the process, specifically by building a reciprocal relationship, favorable to the interests of both parties (Harmon *et al.,* 1997). Technology transfer is carried out through different channels, both formal and informal. The ***formal channels*** include training and education, hiring of students and academic researchers, licenses, sharing of equipment, instruments and external consulting and extension services of universities and research centers (Lockett *et al.,* 2003; Bercovitz and Feldman, 2006). In addition to these, there are also ***informal transaction mechanisms***, such as publications, conferences and exchanges between scientists, researchers and entrepreneurs (Zuniga and Correa, 2013). These transactions are important facilitators and promoters of the innovation process (O'Kane *et al.,* 2014; Cunningham *et al.*, 2017).

It should be emphasized that technology transfer and commercialization do not evolve naturally and linearly from research and scientific breakthroughs. The adverse economic conditions and the inadequate supply of complementary services often pose obstacles to their completion, considering that it is a process with multiple actors and different stages, in which chance might also play a fundamental part. Yet, the benefits for companies adopting the technology transfer paradigm are undeniable (West *et al.*, 2014). The company does not interrupt its internal process of R&D, since it is reliant on its partner, which allows it to obtain intellectual property from one partner and *spin-off* from the other (Harmon *et al.,* 1997). Hence, more partners mean more innovative ideas for new products, methods or processes. The gains from accessing the partner's intellectual property are evident, since the company does not take as many risks or face as much uncertainty (Geuna and Rossi, 2011).

The constant interactions between research entities and companies throughout the innovation process demand a wide range of technological abilities, as well as of transaction and communication channels, which ensure a reciprocate and voluntary knowledge transfer from scientists and engineers to entrepreneurs (Conceição *et al.*, 2012) (*Figure 5*).

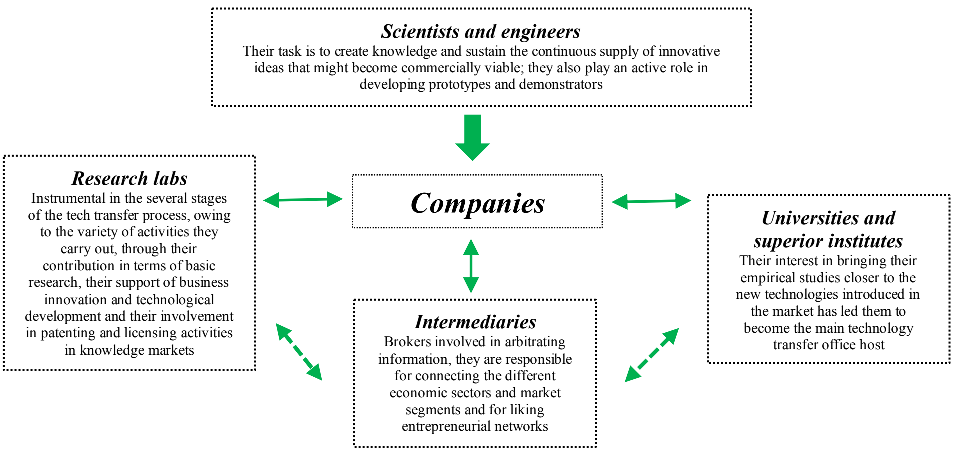
Figure 5: The transaction mechanisms of technology transfer



Source: Own design.

It should be added that technology transfer occurs through the support and active participation of a number of actors and organizations, which play the role of aggregating value to the process, functioning as the "us" in the system. Notwithstanding the variety of contexts and institutional settings, the actors involved in the process carry out activities which involve the production of technological knowledge, the provision of pivotal support services, training, market studies and intermediation (Vásquez-Urriago *et al.*, 2016), detailed in *figure 6*.

Figure 6: The main roles of the actors involved in technology transfer



Source: Own design, based on Vásquez-Urriago *et al.* (2016).

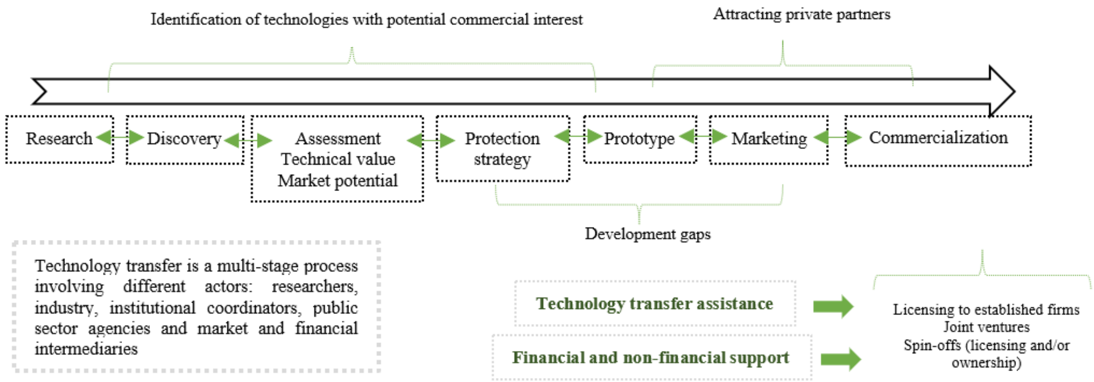
Through the aforementioned channels and actors, the technology transfer process comes to life, with the purpose of *(i)* educating the entrepreneurs through *on-the-job training*, *(ii)* connecting entrepreneurs to markets, capital, clients, partners, suppliers, specialists, certain information and models, by means of introductions and intermediation and by building bonds of trust and credibility, *(iii)* assisting in the identification of technical solutions for technology and innovation consumers, whilst also finding consumers for new innovations, *(iv)* providing consulting services, match-making and mentoring, or *(v)* validating business ideas through strategic orientation and counseling (Scandura, 2016; Martensson *et al.,* 2016).

Technology transfer, particularly its ***commercialization***, does not unfold naturally from basic research to markets (Bozeman, 2000). Keeping this in mind, it should be emphasized that technology commercialization is a process which entails multiple stages and interested parties and that is not necessarily linear, seeing that science-industry relationships may exist from the beginning and science-company interactions may arise at any stage, from conception to the development of the technology (Arora and Gambardella, 2001).

Generically, the starting point is the creation of a sufficiently large and highly qualified range of *outputs*. These *outputs*, in turn, need to be disseminated by researchers, as well as monitored and, at an early stage, preliminarily assessed in terms of market potential. This is followed by the reaching of a decision regarding the need to conduct additional research, until a patent can be filled out and/or the technical viability and the commercial potential can be exhibited by means of demonstrators or the development of prototypes (Allen, 1977; Geuna and Rossi, 2011).

Product development and marketing is the last stage in the commercialization process, corresponding to the actual introduction of new technologies into the market. Companies, public and private intermediaries and investors are *key-partners* who foster the development of *prototypes* based upon applied research. Companies are thus in charge of promoting innovation by getting involved in the production of goods and services (Blalock and Gertler, 2008; Zuniga and Correa, 2013), as can be observed in detail in *figure 7*.

Figure 7: The technology commercialization process



Source: Own design, based on Zuniga and Correa (2013).

Technology commercialization can involve cross-fertilization and synergies in research. Additionally, connections to industry might also have rewarding *outcomes* for research institutions, since collaboration in R&D can lead to complementary studies and even trigger new ideas both for basic and applied research (Debackere and Veugelers, 2005; Martin, 2016). Patent licensing and disaggregation can result in increased access to sponsored researches and new job opportunities for students (Lockett *et al.,* 2003).

Ergo, the benefits associated with technology transfer can be essentially ascribed to the decrease in uncertainty, the joint financing of R&D, cost reduction and the achievement of economies of scale and scope (Hu *et al.,* 2006).

2.3. Public policy for the support of R&D and innovation

2.3.1. The theoretical rationales underlying State intervention

Bearing in mind the relevance of innovation for companies and, consequently, for the entire economy, and taking into consideration the hardships that companies encounter in their innovation process, it is possible to argue that State intervention is required in order to ensure the effectiveness and efficiency of the companies' investment in innovation (Schot and Steinmueller, 2018). As such, in economic and entrepreneurship development policies great importance is attached today to the role played by technological change and by the different kinds of learning that are linked to innovation (Felin and Zenger, 2014).

Considering the definitions ascribed to this broad concept, it should also be added that the ability to manipulate and convert knowledge into new products and processes implicates not only knowledge concerning the development and use of technology, but also knowledge regarding how to meet consumer preferences and trends in different sectors. Therefore, in order to carry out this transformation process, companies make extensive use of collaboration and learning connections to several other NIS entities (Teece, 2011; Magro and Wilson, 2013).

Support policies for science, technology and innovation must be considered precisely in the light of the aforementioned interpretation on what innovation is: a knowledge-intensive process that demands a collective effort and is heavily reliant on technology transfer. Nevertheless, it is important to point out that the reasons that justify the State's intervention in the regulation of innovation activities are different today than they were a few years ago (Padilla-Pérez and Gaudin, 2014; Binz and Truffer, 2017).

Currently, it is presumed that science, technology and innovation cannot be separated. As such, their analysis, formulation and implementation must be broad and integrated (EU, 2014). In this respect, the *core* idea is that policies must be executed considering *three fundamental aspects*: *(i)* the need to conciliate the neoclassical and evolutionary perspectives in an integrated approach, which may result in a blend of support measures and instruments appropriate for the specific situation of each country or region (EU, 2013, 2014, 2016); *(ii)* the need to move past homogeneity and acknowledge companies' heterogeneity and their corresponding contexts (Giannopoulou *et al.,* 2018); and *(iii)* the need for measures that support the system and promote interactivity, as opposed to measures aimed strictly at each type of agent of the system *per se* (Borrás and Laatsit, 2018; Edquist, 2011).

In light of this, it is important, in the first place, to briefly review the ***neoclassical*** and ***evolutionary approaches***, as well as the justification for State intervention in the innovation process. For this purpose, please note that what distinguishes the neoclassical approach from the structuralist one is the fact that the former handles technology as if it were information, which needs to be communicated and conveyed to different agents.

Following Arrow's efforts[3], technology came to be regarded as an endogenous factor. However, the neoclassical line of reasoning acknowledges that endogenous production activities of information technology do not share characteristics with other activities of the economic system and, as such, do not conform to an economic theory

[3] Arrow, K.J. 1962. Economic welfare and the allocation of resources for invention. In National Bureau of Economic Research (Ed.), ***The Rate and Direction of Inventive Activity: Economic and Social Factors***. New Jersey: Princeton University Press, 609- 625.

founded on principles of optimization of the agents' decisions. Notably, in producing information technology, there are indivisibilities in the *inputs* and *outputs*, as well as doubts and uncertainty regarding the time frame during which the transmission and communication of technological information take place.

In addition, information technology displays characteristics of a non-excludable good (*i.e*., the revenues from fundraising activities for information technology are difficult to seize and there is the possibility they will end up in a client or fellow competitor's hands). Information technology is therefore to be considered a public good, with limited and partial appropriability (Martin and Scott, 2000; Laranja, 2007).

The result of this interpretation is the well-known argument concerning the lack of incentives for the agents to innovate, due to the fact that this activity is risky and laden with uncertainty, besides implicating considerable expenses and partial appropriability. Consequently, if private profitability for the innovator is uncertain and potentially low – even though the collective benefits might be potentially high -, this means that the resource distribution mechanisms, mediated by the market, are probably unable to keep up, from the perspective of the collective optimal. Ergo, each agent's investment in technological activities is lower that the optimal level, from the collective point of view – giving rise to the so-called ***market failures*** (Fuentelsaz *et al.,* 2016; Gault, 2018).

In the evolutionary approach, particular attention is given to knowledge transmission and transformation and, consequently, to the cognitive and learning *skills* of different public and private agents. This ability to generate coded knowledge is understood as an additive process which works both at an ***organizational level*** (*i.e*., regarding people inside the organizations) and at a ***collective level*** (*i.e.,* regarding different entity groups which interact through *networking*) (Lundvall, 1992).

In this respect, by making knowledge and learning (and not information) the center of the entire innovation process, the standardized process ceases to exist, being replaced by one that is dependent upon the specific context and circumstances. Hence, a situation that is able to correspond to an optimal state does not exist (Chesbrough, 2003). What does exist, conversely, is the notion that the economic system must have a minimum variety level of companies, as well as public agents and institutions, so that selective forces, such as the market or the social environment, may act, ensuring the system's cohesion and coherence (Laranja, 2007; Santos, 2016).

In view of the *ex-ante* absence of a reference state, it makes little sense to talk about *failures* regarding that optimal state. It does make sense, on the other hand, to make reference to deadlocks, dysfunctions or incoherencies, which convey *trade-offs* between possible different states of the system – the so-called ***learning failures*** (Chesbrough, 2006; Fagerberg, 2004, 2017).

Figure 8 was drafted for the purpose of thoroughly characterizing these conceptual frameworks, by laying out their main reasons and consequences. This differentiation sheds light on their roles in the achievement of certain economic and social goals. Furthermore, it makes it possible to understand their contexts and limitations.

Figure 8: The main reasons for public intervention in the areas of science, technology and innovation and its consequences

<table>
<tr><th></th><th>Neoclassical approach</th><th>Evolutionary approach</th></tr>
<tr><td>Reasons for State intervention</td><td>Increase the amount of information and improve its flow between the agents.

The attempt to replace the market, both in supply (i.e., taking on the innovative activities that are lacking or promoting them through subsidies or tax credits) and in demand (i.e., using public procurement policy).

Promote regulatory mechanisms so as to remove and reduce the obstacles to partial appropriation, thus facilitating internationalization and encouraging the use of the results of the innovation effort on the optimization calculus conducted by the agents. These mechanisms include:
▪ Technological property warranties for the innovator, so that he might be duly rewarded for his efforts;
▪ The promotion of vertical collaboration between technology manufacturers and users, enabling result sharing and decrease in uncertainty;
▪ Horizontal promotion between technology manufacturers, which allows the share of knowledge and costs associated with the risks of technology development.</td><td>The attempt to overcome learning failures, which limit the preservation and further development (improvement) of the actors' cognitive capacity and their interactions at all levels, such as:
▪ Flaws in the exploration and use of technology, which result in poor effort distribution;
▪ Flaws in the selection of good practices and superior technologies, regarding their performance potential;
▪ Gaps in the emergence of companies that may be better than already-existing ones
▪ Flaws in appropriability, owing to improper knowledge codification or recodification
▪ Flaws in knowledge structure, maladjusted to distribution and appropriation needs.

The attempt to tackle cognitive deficit, which results in the lack of minimum conditions for the processes of diversity and selection creation to function properly.

Implement measures and actions for the cognitive development of the actors and provide the necessary conditions for the effective use of this skill.</td></tr>
<tr><td>Consequences</td><td>This approach almost always leads to generic measures and incentives to R&D activities in companies, through subsidies or tax credits.

It mirrors the idea that public risk capital fills the absence of private risk capital for technology-based entrepreneurial initiatives or that financial or task incentives must be given to private risk investors, in order to solve market failures regarding the distribution of risk capital.

The distinction between market failures which are related to scientific activities and the ones that are related to activities which are closer to the introduction of new products into the markets, due to the associated costs/uncertainties.

The way selectivity issues are addressed, with little care being taken regarding the idiosyncratic nature of the innovation process.

The interpretation of additionality issues, which is considered in input and output factors – results and impacts.

Linear model.</td><td>The non-separation between the processes of innovation and diffusion of technology, due to the lack of a division between innovation and diffusion. In the evolutionary world, diffusion is not just a process of purchasing equipment. It is also a process that is equivalent to technological innovation, entailing the transformation of knowledge into new or more efficient processes, products or services.

The borders between innovation policy and other policies, such as education, tax, etc. are blurred because of the interaction between the different agents of the economic system. This precludes a clear separation of the roles played by the different actors, regarding knowledge creation and transformation.

The need for coordination, coherence and complementarity of the political actions between the areas of science, technology and innovation, so that the system may be able to evolve and learn.

The interpretation of additionality issues, considering that what matters is the way the support action is conducted and the specific context in which it is used by the agents, owing to the cumulative nature of knowledge.

Systemic and interactive model.</td></tr>
</table>

Source: Own design, based on Laranja (2007) and Fagerberg (2017).

2.3.2. The evolution of R&D and innovation policy: main historical milestones, framework-programmes and instruments

In parallel with the change in the way the entire innovation process is perceived, the policy which supports it has also undergone countless shifts regarding its priorities and initiatives, in order to meet the interactive approach which has been more recently advocated (Caraça, 2003; Fagerberg *et al.,* 2014). The primary goal has been, Programme after Programme, to adjust the policy measures and/or instruments to the existing needs, so as to respond efficiently to the aforementioned market failures and systemic problems (Fagerberg, 2017) for the sake of social, economic and territorial development designs in the medium to long term (Mazzucato and Perez, 2015).

However, it bears mentioning that, even though there is a current need in Europe for a Community innovation policy, in the early days of the European Economic Community (EEC) (current EU), this policy was incipient (Santos, 2016; Fagerberg, 2017). Chronologically, only in 1984 did the first Framework-Programme for research emerge. Since then, the EU manages its policy and funding in accordance with multi-annual Framework-Programmes (EU, 2013, 2014, 2016).

Portugal's accession to the EEC was the true booster of national scientific research and it is unmistakably evident that the development of the Portuguese innovation policy is inherently connected to the evolution of community policy. In this regard, it is especially from 1995 onwards that the connection between R&D and economy fosters the rise of new forms of knowledge, which might enable the creation of transferable technologies. This occurs when the activity of technology infrastructures starts being considered economically relevant, particularly in the business world, albeit still partially (EU, 2014).

As can be observed in *figure 9*, between 1994 and 2014 five Framework-Programmes were executed. The first and second Community Frameworks invested substantially in the quality and quantity of specialized human resources, as well as in a wider variety of training opportunities in Portugal. However, the idea of producing science and technology, as well as of transferring and disseminating it was still very limited and underpinned by a completely linear reasoning (EU, 2013).

With the third Framework, R&D policy takes a new direction, meeting the priorities of the systemic approach to the process, among which are included stimulating initiatives for technology transfer and the promotion of administrative modernization, which had up until then been neglected in the national context (EC, 2017).

Nevertheless, Portugal adopts a more coherent and cohesive policy, regarding science, technology and economy, with the *National Strategic Reference Framework* (NSRF), in force between 2007 and 2013 and which highlights technological development and the encouragement of entrepreneurship, by integrating and coordinating technology infrastructures and companies (EU, 2014).

In order to completely rationalize this collaborative juncture, the current Support Framework was launched in 2014 – *Common Strategy Framework*: *Portugal 2020* -, putting into practice the principles of *smart, sustainable and inclusive growth*. It attained 1400 million Euros through the *COMPETE 2020* to support research, technological development and innovation and it favors an interaction and collaboration approach, for the purpose of impartially meeting the priorities of Axis *I*[4].

Thus, Axis I stands on *five major goals,* which include:

- ***"Increasing scientific production directed towards smart specialization, technology-based and of high added-value";***
- ***"Enhancing the transfer of scientific and technological knowledge to the business sector";***
- ***"Increasing the investment in business R&D, strengthening the connection between companies and technology infrastructures";***
- ***"Strengthening networks and other types of partnerships and cooperation (clusters);***
- ***"Increasing corporate investment in innovative activities".***

In general terms, the current priority of R&D and national innovation policy is the full promotion of the relationship between technology, innovation and economy, through the joint operation of multiple actors in the process of knowledge circulation (Call no. 57-A/2015). It favors a collaborative approach between technology infrastructures, as parties that produce scientific knowledge, and companies, as *key* parties of the innovation component (Smits and Kuhlmann, 2004; Santos and Mendonça, 2017). It is in accordance with the holistic conceptual framework developed by Lundvall (1992), which contemplates the existence of an institutional-organizational climate favorable to

[4] For more detailed information regarding Axis 1 *vide* www.poci-compete2020.pt/eixos/eixo-i.

technology and innovation and the development of dynamic and competitive *skills*, going beyond the fostering of the traditional indicators of innovation *inputs* and *outputs*.

Figure 9: National innovation policy and the Support Frameworks

Support Frameworks	***Actions and Measures***
1st Framework – 1989 to 1993 *15 Operational Programmes*	The activities which captured more funds were **professional training**, followed by industry and services, transports, agriculture and fishing. Innovation policy fundamentally rested on R&D, taking the shape of *(i)* grants, *(ii)* science and technology parks and *(iii)* technopoles and technological complexes.
2nd Framework – 1994 to 1999 *13 Operational Programmes*	Innovation policy essentially rests upon **scientific research** and encompasses: *(i)* research grants, *(ii)* improved connection to the production sector, *(iii)* the increase in the number of researchers, and *(iv)* the duplication of R&D expenses.
3rd Framework – 2000 to 2006 *19 Operational Programmes*	Innovation policy takes on a new direction with the topic of Science, Technology and Innovation and rests upon *(i)* training and qualification, *(ii)* technological development and the growth of the *network* of R&D institutions, *(iii)* the promotion of technological and scientific culture, *(iv)* the promotion of technology transfer, and *(v)* European and international cooperation.
NSRF 2007-13	Innovation policy rests on **R&D, innovation and entrepreneurship**, encompassing: *(i)* the development of the innovation system through the development of R&D activities and infrastructures, technology transfer, and the improvement of cooperation *networks*, and *(ii)* support and investment in R&D and innovation in SMEs, through the promotion of products and processes with innovative potential.
CSF: Portugal 2020 *16 Operational Programmes*	Innovation policy follows the tenets of the *Europe 2020 strategy* and is executed through **research and innovation**, especially by *(i)* encouraging research, technological development and innovation, *(ii)* capitalizing on the most robust links in the chain of scientific production and knowledge transformation, with the creation of mechanisms which promote knowledge exploration; *(iii)* ***developing scientific research projects of excellence, with a critical scale and in fields endowed with innovation potential and knowledge transfer, thus fostering business innovation capacity and economy's productivity****;* *(iv)* strengthening strategic coordination between the actors of the innovation system, through multidisciplinary cooperation and the use of synergies; *(v)* ***increasing transfer, research conducted between the actors of the system*** and the technical-scientific qualification of high-impact research infrastructures**.**

Source: Own design, based upon EU (2014).

Within the scope of the current support Framework, ***Portugal 2020***, there are several instruments – public incentives or regulatory initiatives – which tackle the above-mentioned market and learning failures and systemic problems[5] (Edquist, 2011; Santos, 2016)[6]. These instruments might also influence the way companies organize their research and innovation activities, as well as the context within which they operate, playing a *key* part in the technology transfer phenomenon (Chesbrough and Bogers, 2014).

[5] For an in-depth description *vide* chapter 3 of this dissertation, titled *"Public system of support to R&D and innovation"*.

Public incentives to companies can, therefore, be subdivided into the following *three major types*: *(i)* task incentives, which lower the tax rate to be paid by the companies (*e.g.* tax credits and accelerated depreciations), *(ii)* direct financing of R&D and innovation projects (*e.g.* subsidies, loans, grants, and other financial subventions) and *(iii)* funding of universities and public labs (Guellec and Ioannidis, 1997).

It is worth noting that ***tax support*** does not require an initial budget, as public support comes in the shape of tax reduction for the companies (*i.e.,* after R&D and innovation activities are conducted) (Hervas *et al.,* 2014). It is, perhaps, less discretionary regarding the type of research to be conducted, since companies have the autonomy to decide which projects to invest in and when. In addition, it is also less restrictive with respect to the type of companies that can access the incentives, encouraging small and medium enterprises (SMEs) to invest, whilst simultaneously saving the State the task and the risk associated with choosing the 'best R&D projects' in public tenders (Ciriaci *et al.*, 2016).

In Portugal, *Tax Incentives for Company Investments in R&D* (SIFIDE) is the public programme in force since 1997 that aims to stimulate the participation of business firms in the overall R&D effort[7]. It was subject to several revisions and two important stages, namely *SIFIDE I* (1997-2011) and *SIFIDE II* (2011-present), which rendered the rise of the overall ceiling of the tax credit on corporate *income* as the main change. As a result, there was an increase in the envisaged raises for investments which allow for job creation and maintenance or contribute to technological innovation (Decree no. 159/2014).

Nevertheless, it is worth noting that this kind of incentive might potentially induce more inefficiency in the use of public resources, besides making it more difficult for the State to estimate and control the sums of the incentives to be granted, the scope of the projects which it supports and their recipients (Godinho, 2013).

On the other hand, ***direct financing*** allocates R&D resources to business sectors, technologies or specific scientific fields, in order to tackle lack of investment, market failure or enhance some existing *skill* that is strategic for public interest. These are logically more appropriate for the purpose of achieving goals related to the State's interest in gaining control over their scope and process (Ciriaci *et al.*, 2016).

[7] For more detailed information regarding *Tax Incentives for Company Investments in R&D, vide* http://sifide.aninov.pt.

From 2014 to 2020, within the scope of R&D and innovation, the financial incentives system for companies encompasses the *three following investment typologies*: *(i)* business innovation and entrepreneurship (Innovation Incentive System – SI Innovation), *(ii)* SMEs qualification and internationalization (SI Internationalization), and *(iii)* technology R&D (R&D Incentive System – SI R&D), featured in *figure 10.*

It bears mentioning that each one of these support systems is designed so as to induce an interactive, dynamic and integrative effect, for the purpose of overcoming the frailties of the last Support Frameworks. These were mostly focused on partially conveying information (*i.e.,* technology/ies) between two or little more than two actors of the system and did not contemplate different types of incentives for companies with different profiles (Call no. 57-A/2015).

All in all, even though economic policies for R&D and innovation support emphasize private initiative and the need to encourage entrepreneurship, government intervention is crucial for the success of private initiative, through specific and diverse types of support which are in accordance with the heterogeneity of the national business reality. It creates a favorable environment for the successful development of private initiative, which in return, has (positive) repercussions on the country's knowledge economy.

In *Chapter 3*, below, a presentation and critical analysis are made of the public programme which will be under particular examination in this research – the *SI R&D* – setting forth its mode of operation, its goals and the available business innovation support instruments.

Figure 10: Enterprise incentive systems in the field of R&D and innovation

	SI Innovation	***SI Internationalization***	***SI R&D***
Object	Structured in *three instruments*: • **Productive innovation not in SMEs**, in line with the investment priority *"Promotion of companies' investment in the development of products and services, in social innovation and eco-innovation"*; • **Qualified and creative entrepreneurship**, in line with investment priority *"Promotion of entrepreneurial spirit, enabling the support to the economic exploitation of new ideas and fostering the creation of new enterprises"*; • **Productive innovation SMEs**, in line with investment priority *"The granting of aid for the creation and broadening of advanced skills of products and services development"*.	Structured in two *instruments*: • **Internationalization of SMEs**, in line with the investment priority *"Development and application of new business models for SMEs, especially regarding internationalization"*; • **Qualification of SMEs**, in line with investment priority *"Granting of aid to the creation and broadening of advanced skills of products and services development"*.	R&D *is in line with priority:* "Promotion of business investment in R&D, **development of connections and synergies between companies**, research and development centers and the higher education sector, specially the promotion of investment in the development of products and services, in **technology transfer, network innovation**, eco-innovation and **open innovation** through smart specialization; support of applied technology research, **pilot lines**, advanced skills of production and first production, and the diffusion of public-interest technologies".
Specific goals	*(i)* To reinforce corporate investment in innovative activities, promoting the increase in tradable and internationalized production and the change of the productive profile of the economic fabric; *(ii)* To contribute to the internationalization and tradable orientation of the Portuguese economy and to the creation of qualified employment.	*(i)* To reinforce SMEs business empowerment through the development of their qualification processes for internationalization, valuing the immaterial factors of competitiveness and allowing for the increase of its base and export capacity; *(ii)* To reinforce SMEs business empowerment through organizational innovation.	*(i)* To increase business investment in research and innovation, strengthening the connection between companies and technology infrastructures; *(ii)* To promote the number of knowledge-intensive economic activities and the creation of value based on innovation; *(iii)* To develop new products and services, in activities of higher knowledge and technology intensity.
National institute of management and coordination			

Source: Own design, based upon Call no. 57-A/2015.

CHAPTER 3
PUBLIC SYSTEM OF SUPPORT TO R&D AND INNOVATION
GOVERNANCE AND ASSESSMENT MODEL

Through the adoption of a normative approach, this chapter pays special attention to SI R&D, by analyzing in detail the integrated and interactive logic of the current system, regarding both the governance model and the selection and monitoring of policy instruments. This analysis is based upon established theoretical and empirical evidence.

SI R&D promotes partnerships and synergies between companies, R&D centers, the higher education sector and other nonprofit organizations, as well as investment in R&D inside the business world, by means of smart specialization[8]. This is a programme which supports and encourages collaborative innovation and the occurrence of technology transfer between the different economic agents, fostering the development of rising sectors and the integration of new technologies in traditional sectors[9].

An analysis will be conducted of the current assessment method, in accordance with May and Wildavsky's (1978) *policy cycle model* and considering this programme as the result of a process which unravels through stages (Rodrigues and Silva, 2012). It should be noted that the breakdown in different steps, which can be studied *per se* or in connection with preceding or subsequent steps, facilitates its understanding and enables an integrated description (Matland, 1995).

3.1. Incentive System for Technological R&D

3.1.1. Governance and Assessment Model

The *Incentive System for R&D* is one of the three transversal incentive systems[10], established for mainland Portugal, with the Programme ***Portugal 2020***, approved by Council of Ministers Resolution no. 137/2014, on September 12th.

This system is in accordance with the priority domains of the ENEI (*Research and Innovation Strategy for Smart Specialization*), emerging as the first strategy which comprehends the development of the system as a whole. Therefore, for the time period that extends between 2014 and 2020, SI R&D is structured in such a way that it enables,

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[8] Approved by Call no. 57-A/2015, February 27th, and changed by Call no. 360-A/2017, November 23rd.
[9] *Vide* www.ani.pt/incentivos for more detailed information regarding the R&D incentive system.
[10] The other two are: Incentive System for Innovation (*SI Innovation*) and Incentive System for Qualification (*SI Qualification*).

objectively and impartially, a structural transformation based upon competitiveness and economy specialization in multiple and interconnected spaces (*i.e.*, on the local, regional and national level) (Call no. 360-A/2017).

In order to foster a systemic development of innovation, a concept of smart specialization was adopted, which exploits agglomeration economies in areas that were consensually considered priorities by the stakeholders involved. The goal is to maximize production and exploit knowledge for the purpose of economic development.

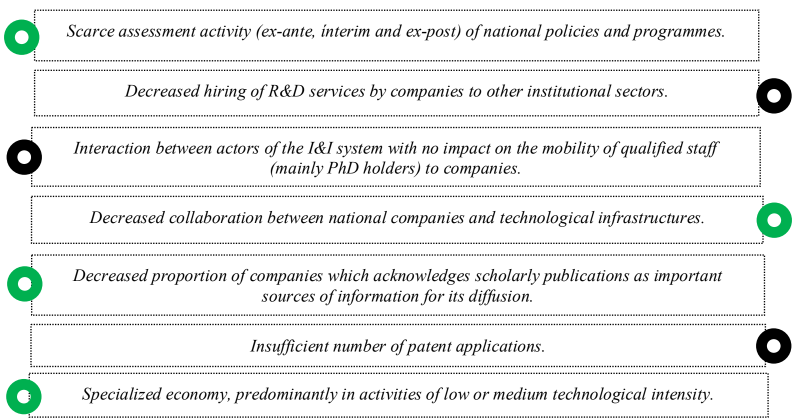
In this regard, geographic and topical proximity are considered, so as to help maintain and reinforce the value chains and *network* connections, which contribute to the occurrence and the development of the dissemination effects on the NIS (Henriques, 2013). This strategy (ENEI) articulates the national sphere with the *five regional strategies*, split into level II Nomenclatures of Territorial Unites (NUTS II) – *North, Centre, Lisbon, Alentejo and Algarve* – in mainland Portugal (EC, 2017).

In its legal core, SI R&D was reshaped so as to enhance the companies' technological research effort and, above all, promote collaborative R&D.

It is currently the main public system for financing the investment on technology transfer in the Portuguese business landscape (Call no. 57-A/2015). Accordingly, priority-wise, SI R&D aims to tackle, through a set of measures and diversified instruments, the main risks and frailties identified in the *Research & Innovation System Diagnosis*, for the NSFR 2007-2013 (Henriques, 2013).

Figure 11 is a summary of the seven more emphasized weaknesses in this diagnosis, which are, in return, the *top priorities* of the *Portugal 2020* Programme in the field of research and technological innovation.

Figure 11: Main weaknesses identified in the NSRF 2007-2013



Source: Own design, based upon Henriques (2013).

According to what is laid out on article 61st of Call no. 57-A/2015, there are *seven project typologies* which are susceptible to incentives, among which, *three* (*i.e.,* projects R&D companies, mobilizing projects and demonstrator projects) specifically promote collaboration between national companies, of any scale or legal nature, and entities that exhibit specialized *know-how* in Portugal and commit to knowledge production (*Figure 12*).

Figure 12: Applying the SI R&D financial instruments (2014-2020)

Instrument typology	***Goals and priorities***	***Nature of the Beneficiary***
Projects R&D companies	Creating or improving products, processes or systems	All types of companies and technological infrastructures
Mobilizing products	Boosting scientific and technological expertise with high content and technology intensity	All types of companies and technological infrastructures
Demonstration projects	Technical validation of advanced technologies and pilot lines, which resort to ***technology transfer*** and activities of technology demonstration and dissemination	All types of companies and technological infrastructures
R&D Teams	Creation and reinforcement of R&D companies' internal *skills* and expertise	SMEs
Intellectual and industrial property protection	Promoting industrial property rights registration in the shape of patents, utility models or trademarks registration	All types of companies
R&D internationalization	Fostering internationalization, by assisting in the elaboration and submission of applications to I&I programmes, funded by the EU	All types of companies
R&D voucher	Purchasing consulting services in R&D activities	All types of companies

The evaluation' object

Source: Own design, based upon Decree no. 41/2015, February 27th.

By considering May and Wildavsky's (1978) ***policy cycle model*** and its *four crucial stages* - outlining the problem and scheduling, devising policy measures and legitimating the decision, implementing, assessing and changing - it is verifiable that each one of these measures was ***scheduled, devised and legitimized***, in view of specific goals, regarding not only the business world *per se*, but especially the science-industry cooperation. It is thus indisputably in line with the integrated approach, resulting in the simultaneous inclusion of the neoclassical and evolutionary perspectives, which was until then strived for in national public policy (Call no. 360-A/2017).

Regarding its ***implementation***, it bears mentioning that the applications were submitted through specific calls, for each one of the previously stated measures. The opening notifications of each one of these calls for applications outlined, among other aspects, the territorial scope and the eligible expenses. The incentive to entrepreneurial investment provided the recipients with financial support of the *non-refundable incentive* *type*[11], barring project exceptions with an incentive higher than 1,000,000.0€ (Decree no. 159/2014; Call no. 57-A/2015; Call no. 360-A/2017).

Once the promoter and project's eligibility requirements – laid out in the SI R&D regulation[12] - are verified, the applications' ***assessment***, ***selection*** and ***ranking*** processes begin. The first assessment is ***ex-ante*** *(i.e.,* it operates in the stage that precedes the implementation of the instrument), which serves the purpose of carefully analyzing its coherence, pertinence and additionality (Call no. 360-A/2017).

According to what is stipulated in article 18th of Call no. 57-A/2015, each one of the aforementioned instruments is assessed by taking into account the domains which underlie the first-grade selection criteria to be approved by the monitoring committees, which cross every measure, save for a few exceptions[13].

The assessment proceeds with the evaluation of the ***merit project***, which currently regards the following *four fields of analysis*: *(i)* Quality of the project, *(ii)* Project's impact on the company's competitiveness, *(iii)* Project's contribution to economy, and *(iv)* Project's contribution for regional convergence. Each one of these areas encompasses, in return, *selection criteria,* as can be observed in *figure 13*.

Figure 13: Merit of the project: dimensions of analysis and selection criteria

Dimensions of analysis	***Selection criteria***
i.*Quality of the project*	***i_1.*** Project coherence and rationality
	i_2. Degree of novelty of the proposed solution
	i_3. Team/Consortium's qualification and adequacy
ii*. Project's impact on the company's competitiveness*	***ii_1.***Project's impact on business strategy
	ii_2.Propensity for international markets
	ii_3.Reinforcement of R&D capacity and innovation
iii.*Project's contribution to economy*	***iii_1.*** Project's contribution to the Operational Programme's results and Portugal 2020's remaining thematic units
	iii_2.Positive externalities
iv.*Project's contribution to regional convergence*	***iv_1.***Degree of alignment with the Regional Strategy

Source: Own design, based upon Call no. 57-A/2015, of February 27th 2015.

[11] Projects with an incentive higher than 1,000,000.0€ *per* beneficiary – non-refundable incentive up until the amount of 1 million euros, with the non-refundable incentive model for a 75.0% portion and the refundable incentive for the remaining 25.0% taking up the amount of the incentive which surpasses this limit. The 25.0% portion is merged into the non-refundable incentive when it falls under the 500,000€ mark (Notification 31/SI/2017).

[12] *Vide* Call no. 57/2015, of February 27th.

[13] With the exception of the R&D vouchers (*Vide* article 18th of Call no. 57-A/2015).

This is followed by the ***ad-interim assessment*** (*i.e.,* that operates at the instruments' development or execution stage), focused on the management and monitoring system, which makes use of assessment criteria that fall into the efficiency and conformity type. In this regard, according to what is laid out in article 124th, which pertains to monitoring and control, "management authority is responsible for supervising the proper execution of the co-financed goods and services and the payment of the expense declared by the beneficiaries, as well as their conformity to the applicable legislation" (Call no. 57-A/2015, p. 44).

To this end, the method adopted to ascertain the results that were reached splits intermediately into *two indicators,* which interlock, namely: *(i)* Degree of technical success in the development of the technology, and *(ii)* Level of deflections.

More specifically, the former allows for the analysis of the degree of fulfillment of technology goals. On the other hand, the latter enables the analysis of the degree of deviation in the project's technology goals, in comparison to what is envisaged in the application, by means of an interim technoscience assessment (Decree no. 159/2014), conducted through the following evaluative structure (*Figure 14*).

Figure 14: Assessment of interim results

		Degree of success			
		Null/Minimal	*Partial*	*Total*	*Surpassed*
Level of deflections	*No deviation in relation to what was estimated*				
	Deviations of little significance				
	Significant deviations				
	Change in scope				

Source: Own design, based upon Call no. 57/2015.

Subsequently, in a final stage, the ***ex-post* assessment** takes place (*i.e.*, conducted in the phase of confrontation with the actual results/achievements and, chiefly, with the production of effects), which employs assessment criteria such as efficiency, effectiveness and adherence (Call no. 360-A/2017; Rodrigues and Silva, 2012).

In this respect, the SI R&D evaluation structure is predicated on the assessment of the economic valuation of the project's results, which encompasses the *three* following qualitative indicators:*(i)* Degree of success in technology commercialization/exploitation, *(ii)* Target-market, and *(iii)* Direct impact on the (post-project) products/customers' portfolio, featured in *figure 15*.

Figure 15: Assessment of the final results

Dimensions of analysis	***Indicators***
i.Degree of success of technology commercialization	***i_1.***Needs new developments
	i_2.In the launching phase
	i_3.In commercial exploitation
ii.Target-market	***ii_1.*** National market
	ii_2. External markets
	ii_3. New foreign/external markets or new customer segments
iii.Direct impact on products/costumers' portfolio	***iii_1.*** Current customers
	iii_2. New customers/same geographies
	iii_3. New customers/new geographies
	iii_4.Created *spin-off*
	iii_5. Not applicable

Source: Own design, based upon Call no. 57/2015.

Following the gathering and description of the currently used methods for the assessment of R&D policy instruments, it is possible to identify several ***technical and methodological limitations***, which can be merged into *two basic categories: (i)* the quality and the manner in which the variables are defined and integrated in the assessment method, and *(ii)* the type of approach taken for its implementation.

It should be mentioned, first and foremost, that despite the effort put into the design of ***ex-ante* assessment** methods, which are ruled by relatively versatile criteria and suited for the measurement of aspects considered urgent and pivotal, its plan is conceived by its more traditional nature, pertaining to a restrictive interpretation of the requirements of community mechanisms (Cunningham, 2007).

These mechanisms are grounded in predominantly qualitative analyses and, not as often, in quantitative analyses of instruments (Call no. 57-A/2015; Vrande *et al.,* 2009). However, its complement is necessary (or shall we say, imperative), particularly in light of the extensive and measurable character of the quantitative indicators, as it would bolster the assessment (Albarello *et al.,* 2011; Creswell, 2009; Lee *et al.,* 2010).

Furthermore, as can be attested in the literature review that was conducted, the idea lying at the *core* of the design and implementation of the current R&D policy shows us that that efficiency and effectiveness of innovation depends on how the actions of the several agents, sectors and regions reinforce and complement one another and on whether there actually are collaborations, as well as formal and institutional connections between the business and non-business entities (Arnold, 2004; Magro and Wilson, 2013).

Nevertheless, even though the *core* of the incentive system is prominently aimed at companies, the current *ex-ante* method does not allow for the assessment of the existence (or not) of a coherent cooperation, which might eventually happen between the various actors taking part in the innovation process. On the contrary, it is a stationary and isolated analysis, focused on the logic of the company *per se*, as a rational element and the only one which grants the optimization of results (Borrás, 2011; Kapil, 2013; Scandura, 2016).

Another crucial and mainly technical issue is the inexistence of an objective analysis criterion, tangible and specifically concerned with the classification of innovation itself (*i.e.,* which pertains to the type of innovation, its nature and technology intensity) (OECD, 2017; OECD, 2018). The *"i2. Degree of novelty of the proposed solution*" criterion partially ascertains the technoscience degree of the developed technology. However, since technological innovation is SI R&D's primary *output*, it would seem careless and inconsistent to disregard a more in-depth and accurate description of innovation itself (Fagerberg *et al.,* 2014; Fagerberg, 2017).

With respect to the ***on-going*/*ad-interim*** assessment, it must be borne in mind that "management authority [in intermediate assessment] is responsible for supervising the proper execution of the co-financed goods and services" (Call no. 57-A/2015, p. 44). Nonetheless, it is clear that the constructed indicators provide an overly simplistic analysis in the face of the unstable and interactive reality of innovation development (Santos, 2016; Borrás and Laatsit, 2018). Moreover, it cannot ascertain in an unbiased and explicit way the fulfillment of the established goals up to the assessment date, skewing the essence of an *on-going* analysis (Arnold, 2004; Edler *et al.,* 2008).

With regard to the ***ex-post assessment***, it is easily discernible that it focuses on the results, specifically on the economic *outputs* and, once more, taking a stance which exclusively regards the company, failing to do justice to the importance of the science-industry collaborative aspect or to put its measurement into practice (Cunningham *et al.*, 2017; Dahler-Larsen, 2012).

It must also be noted that the systemic approach is more concerned with the reasons rather than the results. As such, setting indicators is not as important as acting upon the *causes* – learning, skills, organizational capacity or technical feasibility – which hamper R&D performance, technology transfer and entrepreneurial innovation capacity (Aranguren *et al.,* 2017; Edler, 2007; Edler *et al*., 2012).

Resting upon a new interactive perspective, the final assessment requires that greater focus is given to the measurement of the intangible, to the development and flow of knowledge, to skills enhancement regarding innovation management and to (ascertaining) the promotion of *networks* (Borrás and Højlund, 2015; Edquist, 2011; Van Roy and Nepelski, 2018).

Considering the not very objective nature of the indicators comprising each one of the analyses, the lack of coverage and the static character of its criteria, it is imperative to render the assessment process more complete, systematic, accurate, auditable and realistic (Feller, 2007; Santos*,* 2016).

This is the challenge to which a possible answer will be given next (*Chapter 4*), so that the conditions can be gathered for collaboration in the innovation field to generate actual results, which is a *key* factor in enabling Portugal to attain a better position in the international innovation *rankings*.

CHAPTER 4
DESIGNATED ASSESSMENT METHODOLOGY

By taking into account the weaknesses pinpointed in the previous chapter, it becomes possible to grasp the relevance of exploiting and devising alternative methods, which might arise as development and progress opportunities in the field of policy evaluation in Portugal. Therefore, the current chapter will lay out the main theoretical and empirical principles and techniques which underpin the designated *system-oriented* assessment, which is the focus of this thesis.

The assessment of innovation policies is a *key* process through which the quality, implementation, relevance and impact of the R&D and innovation activities are studied, interpreted and examined (Feller, 2007; Kuhlmann *et al.,* 1999). Investment in R&D within the business world is currently a crucial factor in the development of the economy and the national and regional competitiveness. It has generated a great need for information and diffusion regarding the effectiveness with which its activities are coordinated, the quality of the process and the socioeconomic advantages that come as a result (Binz and Truffer, 2017; Borrás and Laatsit, 2018; Edquist, 2011).

In light of the foregoing, the assessment methods must be as fair and competent as possible and follow elementary requirements, such as precision, coverage, objectivity, congruence and measurability (Gomes, 2016; Hage *et al.*, 2007; Rodrigues and Silva, 2012).

4.1. The assessment object

The assessment object describes the action to be assessed. When the assessment object is a political action, it can fall into the categories of policies, programmes or projects (Caraça, 2003). According to Chesbrough and Bogers (2014), whereas policies define the initiatives, within each initiative there are several programmes which correspond, in return, to guidelines aimed at conforming to public policy priorities. These programmes usually take the shape of projects, which are their operationalization instruments (Caraça, 2003; Gomes, 2016; Santos, 2016).

Following this logic, the assessment's target-programme will be ***SI R&D,*** in the specific category of the ***Demonstrator projects.*** The *three reasons* at the root of this choice are: *(i)* firstly, because this is the project typology which directly fosters the existence of collaborative R&D and technology transfer, *(ii)* secondly, because it is the typology that encompasses projects which have reached a stage of proximity to the market, that is to say the pre-commercialization stage, and *(iii)* thirdly, because these are the projects that better respond to the weaknesses highlighted in the analysis of the Portuguese research and innovation system*,* conducted within the previous Support Framework (Decree no. 159/2014).

Having justified their relevance, it stands to mention that, regarding their ***goals***, Demonstrators are projects led by national companies which develop and demonstrate - against a real background and drawing from successfully accomplished R&D activities - advanced technologies, pilot-lines and prototypes. At the end of the process, actions of diffusion and display of new technologies are carried out in the shape of new products, processes or innovative services, thereby exhibiting their economic and social advantages to a *specific target-group* (Call no. 57-A/2015; Call no. 360-A/2017).

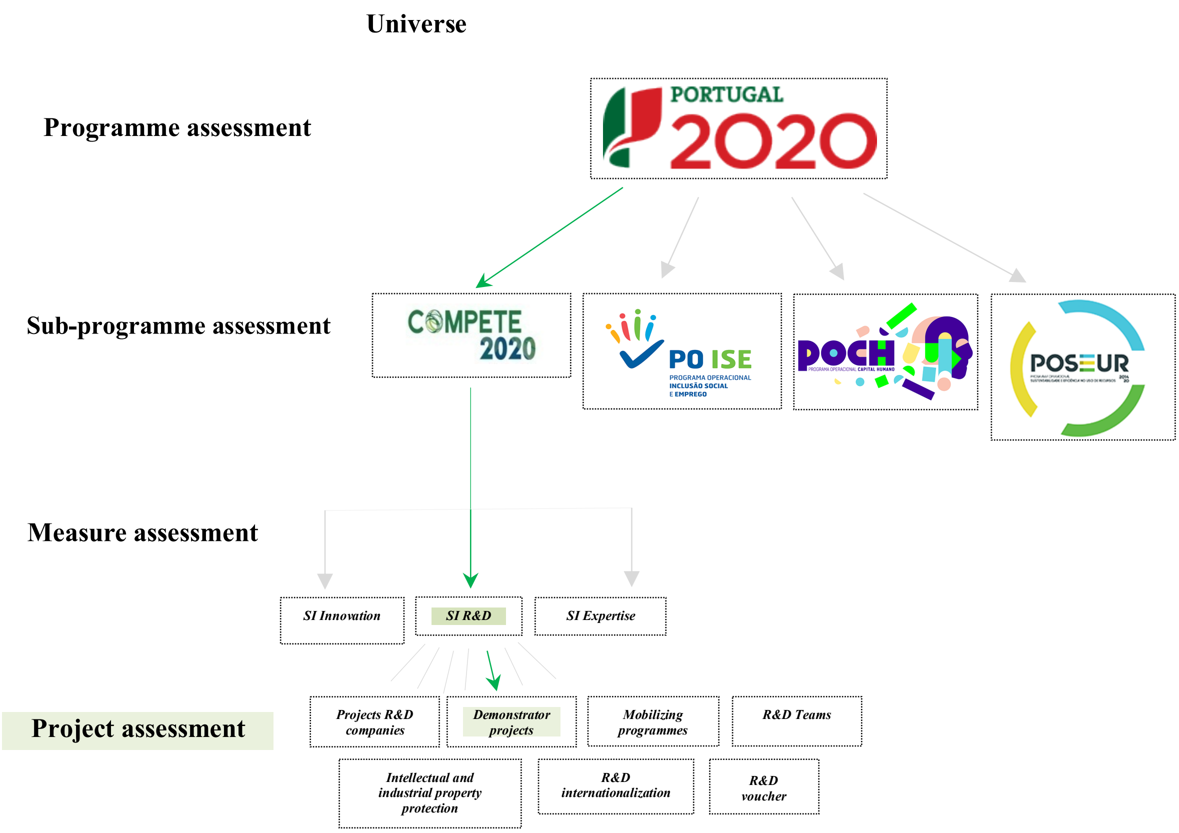
Regarding their ***priorities***, their designs are the diffusion of knowledge, the increase in business cooperation and science-company collaboration, by means of transfer and the use of knowledge taken from R&D to the business world.

In this respect, Demonstrators are open to any type of beneficiary as they're susceptible to adopting any of the following typologies: *(i) co-promotion*, in which case partnerships are established between companies or between companies and technology infrastructures, although mandatorily led by a company; or *(ii) individual*, in which case the demonstrators are carried out by companies of any nature and under any legal form (Notification no. 04/SI/2017; Notification no. 05/SI/2017).

As far as ***geography*** and ***economic sectors*** are concerned, Demonstrators cover the mainland *NUTS II regions* and encompass all economic activities, except for projects within the financial fields, insurances, defense, the lottery and other forms of gambling (Call no. 57-A/2015; Call no. 360-A/2017).

These projects had three notifications for funding, which took place in 2015, 2016 and 2017, with *sixteen projects* being approved in the first year, and *twenty-nine* in each of the respective following years, adding up to a total of ***seventy-four projects***. Each one of the projects has a maximum duration of *eighteen months*, as stipulated in *section e),* of article 66th (Call no. 360-A/2017). So as to regard the course of the assessment as a whole, the process of delimitation and selection of the assessment object is laid out in *figure 16*, which thus takes the ***assessment of project Demonstrators*** as the *unit of analysis*.

Figure 16: Delimitation of the assessment object



Source: Own design.

4.2. Assessment goals

It should be noted that in order for the relevance of collaborative R&D and technology transfer to substantiate itself, the design and the implementation of measures aimed at these phenomena is not enough. It is equally important to conduct an assessment which might ascertain all the hindrances to technological development, through methods which can demonstrate, with credibility, the efficiency and effectiveness of science-industry collaboration and interdisciplinary cooperation in the process of business innovation (Arnold, 2004; Edler *et al.*, 2012; Molas-Gallart and Davies, 2006). Accordingly, the assessment model to be put forward comprises ***three great moments*** in time. The ***first*** is the selection of the applications that are to be funded. The ***second*** is the supervision and corrective monitoring of the corresponding activities. Lastly, the ***third*** pertains to the assessment of results and accomplishment of established goals, as well as to the identification of the main stages and obstacles to commercialization of new technologies developed and funded within the scope of Portugal 2020.

At each of the three above mentioned levels, the assessment object's representativeness is ensured, since the full number (*i.e.*, the universe) of the ***Demonstrator projects*** accepted for public funding during the period in question will be under analysis (2015-2019). Throughout the analyses, ***co-promotion Demonstrator projects*** will be set apart from the ***individual*** ones, for the purpose of concisely ascertaining whether or not collaborative R&D is a rapid and effective route for innovation success, considering that, with regard to economic literature, this reality is theoretically and empirically accepted. Data processing is carried out through quantitative methods, with the use of *IBM SPSS* (*Statistical Package for the Social Sciences*). The main applied techniques will be addressed in detail in the following topics.

4.3. E*x-ante assessment*

4.3.1. The *ex-ante* assessment model

The ***ex-ante* assessment** is strictly concerned with the setting of research guidelines. Currently, the selection of proposals that are to be approved is conducted by means of *peer review* evaluation, a strictly qualitative method which embodies the idea that only specialists who are sufficiently informed regarding the state of knowledge in the field in question (*i.e.*, assessment-experts) have the capacity and *skill* to judge R&D activity and innovation. As such, the assessment of scientific and technological merit is favored, which thus means that the assessment work is conducted independently and separately from public policy priorities (Chubin and Hacket, 1990; Roy and Ashburn, 2001).

Kobarg *et al.* (2019) emphasizes that both the guarantee of scientific quality and the priority areas for the country's socioeconomic development must be considered and made to intervene simultaneously, which is indispensable to the assessment process.

According to Borrás and Laatsit (2018), a *system-oriented* assessment entails the introduction of a new quantitative dimension to the analysis, as well as the inclusion of all the agents involved in the process, both internal and external, so as to ascertain the utility and importance of their participation in the results.

Given the above stated, a ***methodology was designed*** to be applied in the stage of selecting the applications, adapted to the new paradigm of technology transfer, which includes a range of intimately connected aspects of analysis and entails the active participation of *multiple stakeholders*. These include not only *experts* (*i.e.,* engineers or scientists), but also technicians and management, economy and finance specialists, well-versed in the current market dynamics and capable of accomplishing a more solid and transparent assessment, through cooperation (*vide* Smits and Kuhlmann, 2004).

The *ex-ante* assessment is ergo predicated on the following ***three research techniques***, of an intensive and exploratory nature: *(i) documentary analysis*, namely the analysis of technical appendixes corresponding to each notification for the projects[14], for the purpose of fulfilling the established legal and technical information of a compulsory nature; *(ii) the thorough analysis of the seventy-four project applications*, so as to get acquainted with its structure, work plan, involved entities and innovative proposal*;* and *(iii) constant direct contact and interaction with its coordination and management entity* (*i.e.,* ANI), with superior management technicians, experts and specialists in the different areas that comprise the Demonstrators, members of the Administrative Board and economists, throughout a *four-month* period.

By resorting to the technical appendices of the projects' application proposals, it was possible to conceive *a* ***new project merit referential***, now oriented towards the systemic aspect of the process.

This *new referential*, which is laid out here, is devised through the use of *five dimensions of analysis*, namely: *(i)* Coherence and rationality*, (ii)* Intensity and adequacy of R&D *inputs, (iii)* Degree of novelty of innovation activities*, (iv)* Scope of R&D *outputs* and diffusion*,* and *(v)* Impact on business competitiveness and economy.

A short explanation of each one of the constructed *dimensions of analysis* follows[15].

i. Dimension *Coherence and rationality*

The first dimension attempts to ascertain what *type of leading company* is investing in R&D and striving to innovate, the *activity sector* in which it belongs, the *number of co-promoters* involved, as well as whether or not the project is well structured regarding the *tasks* that are be conducted in face of the established goals, whether it contains the necessary *financial resources* and makes use of the most adequate *techniques*, in scientific and technological terms, for its accomplishment.

[14] Within the scope of *Portugal 2020*, for the Demonstrator projects, Notification no. 09/SI/2015, Notification no. 10/SI/2015, Notification no. 31/SI/2015, Notification no. 32/SI/2015, Notification no. 04/SI/2017 and Notification no. 05/SI/2017 were published.

[15] In appendix I the *'new project merit referential'* which coordinates the *ex-ante* analysis proposed in this thesis is laid out. This appendix exposes thoroughly and minutely each one of the *domains of analysis* and corresponding *selection and assessment criteria.*

ii. Dimension *Intensity and adequacy of R&D inputs*

The second dimension aims to analyze the adequacy of the *human resources* which comprise the teams or consortiums, the *type of entities* involved in the process, as well as the measuring of *R&D capacity reinforcement* regarding new hires for the companies and the *expertise of the projects' teams*.

iii. Dimension *Degree of novelty of innovation activities*

The third dimension seeks to evaluate the *type of innovation*, its *nature* and *class*, *R&D technological intensity*, the *technology fields* in which it will be integrated and/or be applied, and the *degree of complexity* that its development entails, so as to make an accurate and in-depth description of the innovation that is to be developed.

iv. Dimension *Scope of R&D outputs and diffusion*

The fourth dimension concerns the innovation *outputs*. It assesses the registration of the application for *registration of intellectual and industrial property*, specifying the *type of protection*. It aims to analyze the prospective *positive externalities* to be generated, as well as the foreseen *effects of dissemination* and *diffusion*. It also evaluates the plan of diffusion and *economic valuation of results*, in terms of its quality and effectiveness.

v. Dimension *Impact on business competitiveness and economy*

The fifth dimension assesses the impact of innovation funded at micro and macro level. In microeconomic terms, it seeks to evaluate the *organization's strategy regarding internationalization* or its reinforcement. It also attempts to measure its projection in terms of *post-project R&D investment* and the *gross value added* (GVA) which will be reached with the development of the innovation. In macroeconomic terms, its aims to ascertain the estimate the *contribution of innovation to national economy* and analyze its *effect on regional and sectorial convergence*, considering the priority domains of Portugal 2020 and its degree of alignment with these.

Having defined the dimensions of analysis, the corresponding indicators were constructed (here called *selection criteria*), which might allow their measurement (Albarello *et al.*, 2011; Hudson and Fraley, 2014). *Figure 17* displays the full operationalization table which lays the foundation for the *ex-ante* assessment.

Figure 17: *New project merit referential* – dimensions of analysis and selection criteria

Dimensions of analysis	Selection criteria	Legal and empirical sources
i.Coherence and rationality	i_1.Type of leading company i_2.Number of co-promoters i_3. Sector of activity i_4. Work plan i_5.Scientific and technological methodology i_6.Investment plan	***Technical and empirical sources:*** *CIS - Community Innovation Survey (2018), Doh and Kim (2014), Geroski (1990), Lee et al. (2010), McGuirk et al (2015, Oslo Manual (2018), Scandura (2016) and Schumpeter (1982).* ***Legal sources:*** *Notification no. 04/SI/2017 and Notification no. 05/SI/2017.*
ii.Intensity and adequacy of R&D inputs	ii_1.Parties involved ii_2.Team's expertise ii_3. Team's adequacy ii_4. Need to subcontract activities ii_5. Reinforcement of R&D capacity regarding new appointments ii_6. Engagement of PhD holders	***Technical and empirical sources:*** *Amesse and Cohendet (2001), Arora and Gambardella (2001), Bozeman (2000), Edquist (1997), Schot and Steinmueller (2018) and Tether (2002).* ***Legal sources:*** *Notification no. 04/SI/2017 and Notification no. 05/SI/2017.*
iii. Degree of novelty of innovation activities	iii_1. Type of innovation iii_2. Class of innovation iii_3. Nature of innovation iii_4.Technological field iii_5. R&D technological intensity iii_6. Degree of technological complexity	***Technical and empirical sources:*** *Dosi (1988), Fagerberg et al. (2014), Frascati Manual (2017), Freeman and Perez (1988), Kovács (2000), Oslo Manual (2018), and Hölzl (2008).* ***Legal sources:*** *Notification no. 04/SI/2017 and Notification no. 05/SI/2017.*
iv.Scope of R&D outputs and diffusion	iv_1. Intellectual property registration iv_2. Type of protection iv_3. Positive externalities iv_4.Effects of dissemination and promotion iv_5.Economic valuation of results iv_6.Technology transfer intensity	***Technical and empirical sources:*** *Fagerberg (2017) and Martin (2016).* ***Legal sources:*** *Notification no. 04/SI/2017, Notification no. 05/SI/2017 and Call no. 360-A/2017.*
v.Impact on business competitiveness and national economy	v_1. Business strategy v_2.Propensity for international markets v_3. Contribution to national economy v_4. Post-project investment on R&D v_5.Contribution to the national strategy of smart specialization v_6. Regional and sectorial convergence	***Technical and empirical sources:*** *Aranguren et al. (2017), Dahler-Larsen (2012) and Scandura (2016).* ***Legal sources:*** *Notification no. 04/SI/2017, Notification no. 05/SI/2017, Decree no. 159/2014 and Call no. 360-A/2017.*

Source: Own design.

Given the fact that the primordial goal of this thesis is to ascertain whether collaborative R&D and technology transfer contribute to the outreach of more innovative projects and for their successful commercialization, the following guiding **hypotheses of this research** in the ***ex-ante*** **assessment** are accepted:

H_1: It is expectable that *co-promotion* projects present better-elaborated work plans, scientific and technological methodologies and investment plans.

H_2: It is expectable that *co-promotion* projects are comprised by entities that are better qualified and more adequate to the designated innovation, with no need to subcontract resources external to the team.

H_3: It is expectable that *co-promotion* projects potentiate innovations with higher degree of novelty in fields of high-intensity technology.

H_4: It is expectable that *co-promotion* projects are more prone to generating positive externalities for economy, with more preeminent effects of dissemination and valuation of results.

H_5: It is expectable that *co-promotion* projects contribute more predominantly to national competitiveness, following primarily Portugal 2020's priority domains.

4.3.2. Applying the *ex-ante* assessment model

The creation of the *new referential* was followed by its ***implementation***. Firstly*, seventy-four datasheets* are devised for each one of the Demonstrator projects. These sheets are based upon the application proposals devised by each project. Their creation, therefore, entailed a reading and an intensive and detailed analysis of these proposals. Their thorough execution entails several *informal meetings with management technicians and experts* from a number of technological fields.

Subsequently, each project is rated, with a *score* being assigned to each one of the different selection criteria, on a *Likert scale* of 1 to 5 points (*i.e.,* in which *1* corresponds to the *lowest score* and *5* to the *highest*)[16] (Notification no. 31/SI/2017).

The *weighted arithmetic-mean* of the quotations achieved in the applications is used, with the importance assigned to each field of analysis as the weight (w_I), which was stipulated according to the opening notifications of the applications, and agreed upon, unanimously, by the author of this thesis, management technicians of ANI projects and assessing *experts*.

In comparison with the simple arithmetic mean, this type of approach is legitimate in the current study, since not all dimensions contribute equally to the national and regional goals of the innovation policy[17] (Albarello *et al*., 2011). This important distinction is considered herein.

The *new project merit referential* is, therefore, calculated in the following way:

$$\overline{\boldsymbol{Project\ merit}} = \boldsymbol{0.3i + 0.2ii + 0.1iii + 0.1iv + 0.3v}. \qquad \textbf{(1)}$$

[16] The *scores* that were reached by the Demonstrator projects, in accordance with the *new assessment referential*, are laid out in *Appendix IV*. The two project typologies are clearly differentiated.

[17] *Appendix V* shows the final scoring attained by the Demonstrator projects, according to the weightings stipulated for each dimension of analysis. The two project typologies are clearly set apart, as well as the highest and lowest final scorings.

It should be emphasized that the five aforementioned dimensions are not totally independent from one another, mutual influences occur – in parallel to the current conceptualization of the innovation process as 'interactive and dynamic' (Chesbrough, 2003, 2006; Lee *et al.,* 2010). This scenario might be confirmed or informed in the following chapter, where an analysis of the results will be conducted.

4.4. *Ad-interim* and *ex-post assessment*

4.4.1. *Ad-interim and ex-post assessment model*

Following the selection and assessment of the projects, the R&D activities which must occur with some assistance begin. The ***ad-interim*** **assessment** can function as an important management instrument, considering that it takes place during the project's execution and aims at the control of its performance (Liao and Witsil, 2008).

After the project is finished, the funding intermediate entity (*i.e.,* ANI) and the researchers themselves should grasp at the extent to which the expected results were achieved. In this regard, the ***ex-post*** **assessment** includes the analysis of the way each activity's means and resources were used in face of the goals that were initially set, in the application stage. Its main purpose is, therefore, to assess the relevance, effectiveness and impact of the project following its conclusion, focusing on its success factors and the main obstacles/impediments met throughout the process of technological development (Cooper *et al.*, 1997; De Coster and Butler, 2005).

As was possible to observe in the previous chapter, the currently used method focuses on the *outcomes* and *outputs* reached with the innovation and on its impact on the business portfolio of the enterprises. Nevertheless, it cannot specifically evaluate the reasons which led to the success or failure of each project, the way the entities explore and manage the process, the technical feasibility of the innovation in face of the current internal and external conditions, or the main drawbacks which hindered their commercial success.

Bearing in mind the frailties and risks of the current *ad-interim* and *ex-post* assessments and their possible repercussions, this thesis proposes a new intermediate and final assessment method, directed towards a holistic perspective which every project requires nowadays, through the application of ***Innovation Radar***.

Launched in August 2013 and improved in conceptual and methodological terms in 2018, *IR*, a joint support initiative, taken up by *Directorate-General for Communications Networks, Content and Technology* (DG CONNECT) and EC's *Joint Research Centre* (JRC), attempts to tackle these limitations by setting forth robust indicators which reveal more about the activities, models and innovation strategies than the oversimplified indicators that were formerly used (De Prato *et al.,* 2015; Van Roy and Nepelski, 2018).

This methodology, which is applied to the evaluation of projects of *Horizon 2020* and the *7th R&D Framework Programme*, focuses on the identification and assessment of high-potential innovations and their corresponding innovators, besides promoting the proper guidance of project teams so that innovation can successfully reach the market (JRC-IPTS, 2014; McFarthing, 2015).

Innovation Radar is, therefore, applied to projects which are in different stages of their life-cycle (both in intermediate and final moments), aiming chiefly at: *(i)* the estimation of the innovation potential of developed and funded technologies; *(ii)* the assessment of the innovation capacity of the organizations behind this process; and *(iii)* guidance regarding the most appropriate steps to reach the market, identifying the obstacles and barriers to their actual commercial use (De Prato *et al.,* 2015; Wilson, 2015). Thus, by employing this tool, it is possible to maximize private investment results and, in turn, optimize direct financing of innovation, in a more precise and coherent way.

In technical terms, this methodology includes *two dimensions of analysis*, which are: *(i)* the assessment framework for the classification of innovation regarding their potential, and *(ii)* the assessment framework for a *ranking* of innovative companies in terms of their quality and their capacity to innovate.

A short explanation of the structure and theoretical premises of the two abovementioned components follows.

i. Dimension *Innovation Potential*

Innovation potential is *Innovation Radar*'s first dimension of analysis, which encompasses a range of indicators and pre-established criteria aimed at assessing the strength and progress of each technology. It strives to answer questions like *"Will this technology work?"*, *"Is the technology ready to be commercialized? What is missing?"* or *"How well-protected is the competitive advantage?"*. As such, so as to provide comparable results for analysis and interpretation, this dimension focuses on *three* fundamental assessment criteria, which are: ***(i$_1$)*** *innovation readiness*; ***(i$_2$)*** *innovation management*; *and* ***(i$_3$)*** *market potential*.

(i$_1$) Innovation readiness (IRI) is concerned with the technical maturity of the evolving technology, targeted at ascertaining the development phase of the latter (Astebro, 2004; Evanschintzky *et al.*, 2012). Essentially, it aims to capture the multiple technological stages that the process of innovation development entails. These stages encompass creating ideas, establishing new products or services, sorting concepts and developing prototypes and tests, the diagnostic evaluation and final development (Cooper, 2007).

The development process of new and improved technologies is based upon the joint efforts of a number of participants. Technology transfer is, thus, considered a crucial step in the process of technology commercialization, both in a formal way and through informal channels (Grimpe and Fier, 2010). It is, therefore, considered.

(i$_2$) Innovation management (IMI) addresses the existence (or not) of a competent team in the project, as well as its commitment in bringing technology to the market. Hence, its goal is to assess the ability of the promoting entities to turn technology into a product, method or marketable service, including issues regarding intellectual and industrial property rights, the elaboration of a business plan or market study, guarantee of capital investment from public and private sources, among other related aspects (Gerard *et al.,* 2002; Christensen, 2010; Kirchberger and Pohl, 2016).

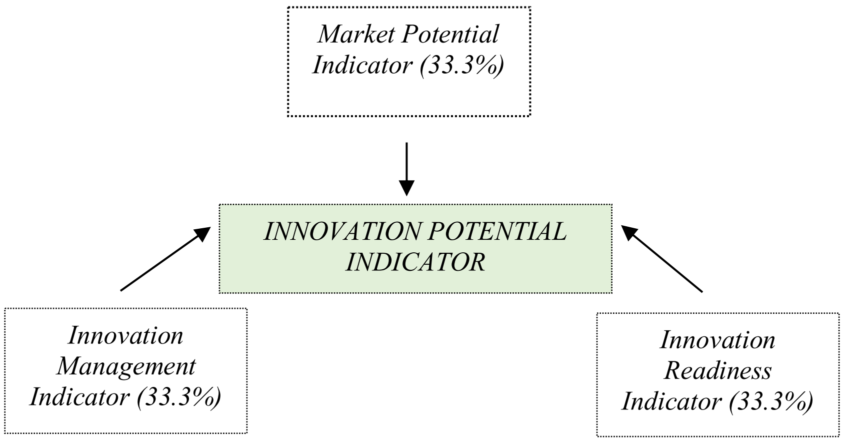
In broad terms, it is concerned with the various skills of team management, risk management, absorptive capacity and knowledge management. Innovation management is vital for the conflation of the necessary conditions for the management of ideas and business proposals, and it should not merely stick to internal resources, but also consider interactions with external actors. Its approach is that of a clear commitment and direct and sustained engagement between all humans' resources involved in the project (Evanschitzky *et al.*, 2012).

Finally, ***(i$_3$)*** market potential (MPI) addresses market dynamics, namely the demand and supply perspective of innovative technologies. In respect to demand, specifically, it refers to the prospective market conditions and chances of success in its commercial use, by assessing how a technology covers a certain market sector and whether or not there is a potential customer base. Regarding supply, it seeks to evaluate if there are any potential obstacles which might weaken the commercial exploitation of technology, pinpointing them (Goldenberg *et al.,* 2001). Thus, market potential mirrors the likely economic and social value which might be generated by the new funded product, service or process (Blind, 2011, 2016).

The innovation potential indicator (IPI) – schematized in *figure 18* – is constructed from these. It is an arithmetic mean which aggregates the value of the *three* aforementioned criteria, with all elements being weighed in equally, as follows:

$$\boldsymbol{IPI = \tfrac{1}{3}\,IRI + \tfrac{1}{3}\,IMI + \tfrac{1}{3}\,MPI}. \qquad \textbf{(2)}$$

Figure 18: Construction of the innovation potential indicator



Source: JRC-IPTS, 2014.

ii. Dimension *Innovator Capacity*

This second *Innovation Radar* dimension, innovator capacity, is the foundation of the assessment for the innovators' *ranking* and is focused on answering two questions: *"What is the innovation performance of key-organizations involved in the projects?"* and "*In what kind of environment are these organizations located?"*

As is the case with the innovation potential dimension, this also encompasses criteria which aim at assessing the capacity of the parties involved in the development of technologies (Polt *et al.*, 2008; Teece, 2011; Forsman, 2011). For this purpose, it makes use of *two impartial assessment criteria*, which are: ***(ii_1)*** *innovator's ability*; and ***(ii_2)*** *innovator's environment* (Hull and Covin, 2010; Fernandes *et al.*, 2013).

(ii_1) Innovator's ability (IAI) concerns the inherent innovation capacities of the beneficiary companies (Assink, 2006). It is crucial for the assessment of an innovation, since the speed with which an organization responds to the changes in market conditions and needs, through the conception and launching of new or improved products/processes is contingent upon the learning capacities of the promoting entities (Hull and Covin, 2010).

This criterion is, thus, connected to the performance of the leading company that is behind the development of the innovative technology, taking into consideration factors like its independence and leadership in the achievement of the designated goals and its relationship with other promoters, in case they exist (Hölzl, 2008; Cucculelli and Ermini, 2012).

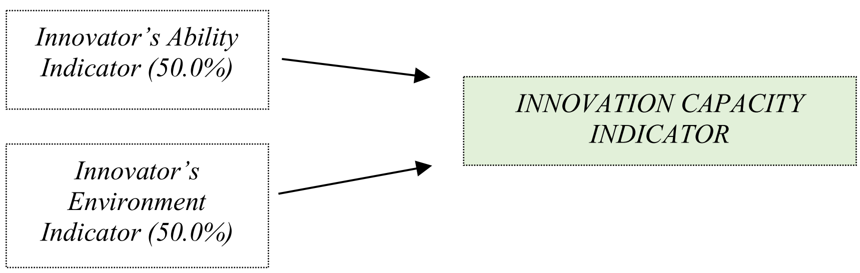
(ii$_2$) Innovator's environment (IEI) aims at capturing the overall conditions, internal and external, which the innovative company faces, such as the existence (or not) of partnerships, the number of partners and their commitment to exploiting technology.

It should be noted that working in collaboration with other organizations enables the flow of complementary ideas and assets, the mobilization and channeling of additional resources (*e.g.* information), as well as the reduction of risks associated with R&D projects (Carayol, 2003). In this regard, innovation projects which entail collaborative research enhance the innovative capacity of the partners in question. It is, thereby, assumed that a positive environment has positive repercussions on the innovative entity(ies) and *vice-versa* (Röller *et al.*, 2007; Pandza *et al.*, 2011).

As can be observed in *figure 19*, the innovator capacity indicator (ICI) is created through the arithmetic mean of the *two* abovementioned criteria, in the following way:

$$\boldsymbol{ICI = \frac{1}{2} IAI + \frac{1}{2} IEI}. \qquad \textbf{\textit{(3)}}$$

Figure 19: Construction of the innovator capacity indicator



Source: JRC-IPTS, 2014.

Considering the fact that *co-promotion* projects strongly rely on the technology transfer phenomenon, the following can be considered the guiding **hypotheses**[18] of the ***ad-interim*** **and** ***ex-post*** **assessments**:

H_A: It is expectable that *co-promotion* projects exhibit levels of innovation readiness that are more advanced and closer to the stage of commercial use, displaying higher innovation potential.

H_B: It is expectable that *co-promotion* projects show stronger capacities of R&D and knowledge management, exhibiting higher innovation potential.

H_C: It is expectable that *co-promotion* projects generate more added value and more socioeconomic benefits to the market, displaying higher innovation potential.

H_D: It is expectable that *co-promotion* projects have greater capacity to generate new ideas and turn them into solutions that might respond to market demands, showing increased organizational capacity of innovation.

H_E: It is expectable that *co-promotion* projects mobilize and disseminate more learning resources and knowledge, exhibiting greater organizational capacity of innovation.

4.4.2. Applying the *ad-interim and ex-post assessment model*

Having presented the two dimensions and corresponding assessment criteria, it is time to focus on how they are applied. The starting point of this tool is the application of a ***survey questionnaire***, which was designed by DG CONNECT[19]. Even though it is the initial research stage, establishing the questionnaire is a crucial step. In a way, it is both the end point of a reflection and the point of departure for subsequent analyses. Each dimension and corresponding assessment criteria are represented by a set of questions in the *survey questionnaire*, which displays a relatively homogeneous constitution (De Prato *et al.*, 2015; McFarthing, 2015).

It is comprised of *close questions*, which are easily understood and leave no space for ambiguity; *open questions*, which do not have a predicted answer, enabling greater freedom in the response, despite the fact its tabulation is more complex and demands previous encoding; *semi-open questions*, a combination of the former two, the submission of multiple response options; and *scenario-based questions*, which introduce a variety of possible or existing situations, minutely and thoroughly described, for the respondents to

[18] Each one of the abovementioned hypotheses is in line with the *dimensions of analysis* and corresponding selection criteria which are at the *core* of the designated *ad-interim* and *ex-post assessment.*
[19] The *Innovation Radar questionnaire* is laid out in *Appendix II.*

choose the scenario that most closely corresponds to their vision (Albarello *et al.,* 2011; Wilson, 2015).

The *questionnaire* must necessarily be conducted in person, through a technical visit to each one of the projects' beneficiary leaders – implying ***participant observation*** (Mairesse and Mohnen, 2010; Hong *et al.*, 2012). This visit entails the participation of the author of this thesis and of at least one *expert* specialized in the field to which the developed innovation belongs (Van Roy and Nepelski, 2018).

Its application is followed by the ***scoring system***[20], created so as to neutrally and thoroughly rate the developed technologies' potential, as well as the innovator capacity of their promoters. Drawing from this stage of analysis, it is possible to assess and construct the dimensions of analysis – IPI and ICI – for each Demonstrator project (De Prato *et al*., 2015).

So as to enable comparisons with other typologies of R&D projects, assessment by means of *Innovation Radar* introduces *three categories of innovation: (i)* low potential innovations, *(ii)* medium potential innovations and *(iii)* high potential innovations (*Figure 20*). By sorting innovations and innovators into three different categories, according to percentile ranks, allows their performance to be compared with the remaining innovations and innovators within the universe of *Portugal 2020* projects.

In formal terms, this can be expressed as follows:

$$\textbf{\textit{Low Potential Innovation:}} \quad IPI_i < IPI_{Mean} - IPI_{SD'}, \tag{4}$$
$$\textbf{\textit{Medium Potential Innovation:}} \quad IPI_{Mean} - IPI_{SD} \leq IPI_i < IPI_{Mean} + IPI_{SD'}, \tag{5}$$
$$\textbf{\textit{High Potential Innovation:}} \quad IPI_{Mean} + IPI_{SD} \leq IPI_{i'}, \tag{6}$$

where *i* is the observed IPI *score* of innovation and mean and SD are average and standard deviation of the IPI.

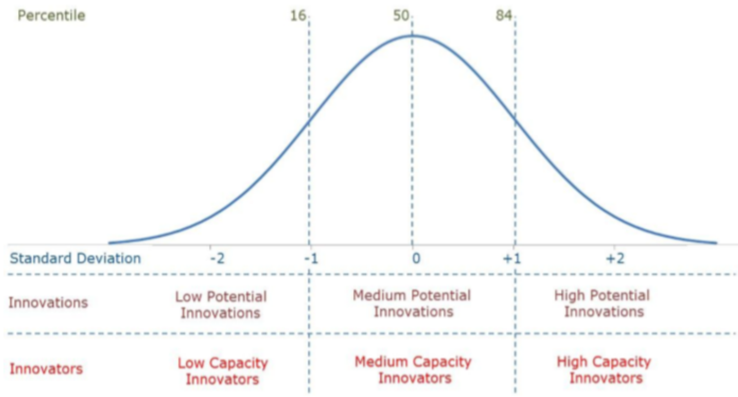
Following the same logic, the assignment of inventors to *three categories* is based on the following rules:

$$\textbf{\textit{Low Capacity Innovator:}} \quad ICI_j < ICI_{Mean} - ICI_{SD'}, \tag{7}$$
$$\textbf{\textit{Medium Capacity Innovator:}} \quad ICI_{Mean} - ICI_{SD} \leq ICI_j < ICI_{Mean} + ICI_{SD'}, \tag{8}$$
$$\textbf{\textit{High Capacity Innovation:}} \quad ICI_{Mean} + ICI_{SD} \leq ICI_{j'}, \tag{9}$$

where *j* is the observed ICI *score* of innovators and mean and SD are average and standard deviation of the ICI.

[20] The *Matching survey questions with assessment criteria* is laid out in *Appendix III;* the scoring achieved in *ex-post* assessment is laid out in *Appendix VI.*

Figure 20: Categories of innovations and innovators



Source: JRC-IPTS, 2014.

Through this assessment, an overall view is provided of the innovators' needs in attending to market potential and proper guidance is given toward is commercial success (Van Roy and Nepelski, 2018).

This is followed by the implementation of the provided assessment methodology, with the observed results being discussed, in the two stages of the analysis, as well as their implications for the theme of innovation and for national economy (*Chapter 5*).

CHAPTER 5
ANALYSIS AND DISCUSSION OF RESULTS

Good coordination between the different stages of the political cycle and the promotion of a favorable environment for innovation technology activities greatly rely on the thoroughness of the formulation and implementation of support policy measures and instruments, but also on the achievement of a competent assessment, aimed at all the *stakeholders* involved in the innovation system (Chesbrough and Bogers, 2014; Fagerberg, 2017).

It should be emphasized that, in addition to the creation and application of a more robust and extensive assessment model in a real context, the goal is also to understand whether more intense collaboration and technology transfer foster innovation projects with *higher degrees* of *coherence*, *suitability*, *novelty* and *technological diffusion*, and whether they are impactful on the *micro* and *macroeconomic levels*. Subsequently, at the projects' final stage, through the *ex-post* assessment model, the aim is to ascertain whether co-promotion projects actually led to more promising and commercially successful innovations.

Notwithstanding the fact that *chapter 2* presents theoretical evidence regarding the relevance of knowledge flows and collaborative R&D, there is a clear need for the empirical confirmation of this research's leading hypothesis, which refers to these phenomena and their effects on the multiple *spheres* under consideration. Statistical analysis will thereafter make it possible to answer the initial question driving this study: ***"Are collaborative R&D and technology transfer rapid and effective pathways towards the success of innovation?"***

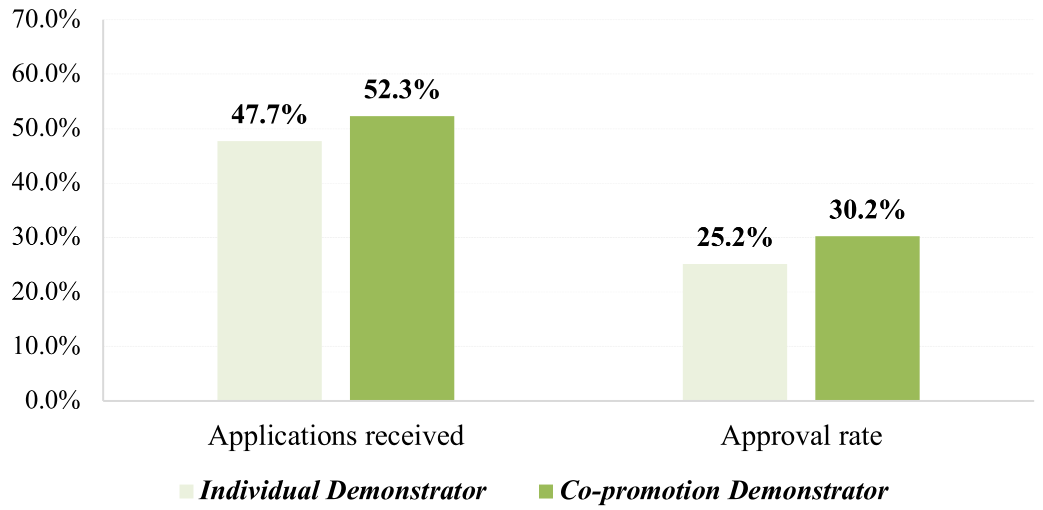
The current chapter is split into the following *three crucial topics*: *(i)* the presentation of the Demonstrator projects eligible applications, the overall investment that was made and the support provided, according to project typology and continental Portugal's *NUTS II* regions; *(ii)* the analysis of the relevance and pertinence of the goals established in the applications, of the coherence of their resources and the efficiency of their accomplishments; and *(iii)* the analysis of their effectiveness in the market (*i.e.,* their *outcomes* on the technical, business and commercial levels), by applying the *Innovation Radar* questionnaire in public sessions aimed at delivering the results of the Demonstrator projects.

5.1. Eligible applications, investment and financial incentive

SI R&D received 2059 application proposals for the seven measures in force in the current community Framework, matching a total sum of 6027 national promoters (*i.e.*, enterprises and scientific and technological entities). Among the overall number of received applications, 266 *innovation projects* applied for the Demonstrator projects typology, encompassing a total amount of 638 promoters in public tender.

In the 2015-2019 period, the management bodies and the selection committee[21] issued positive assessments on ***74 applications***[22], submitted by companies to SI R&D, in the Demonstrator projects[23] typology. Among these, 42 belong to co-promotion projects and 32 to individual ones, which represents an average approval rate of 30.2% and 25.2%, respectively (*Figure 21*).

Figure 21: Application proposals and approval rate, according to Demonstrator project typology (2015-2019)



Source: Own design based on data extracted from ANI's SI R&D platform.

The *NUTS II* region of Continental Portugal[24] which has implemented more innovative projects**,** for both Demonstrators, was the Centre (50.0%). There were, however, considerable differences in the other regions, regarding project typology.

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[21] The selection committee is the body that coordinates and manages R&D and innovation policy measures and instruments – ANI.

[22] The sum total of applications encompasses both the ones under the tutelage of the *Regional Operational Programmes* and the *COMPETE* ones.

[23] The average approval rate was approximately 27.8%.

[24] The geographical location refers to the regions of project implementation and not to the *Regional Operational Programme* which finances them.

In co-promotion projects, 47.6% were implemented in the North (35.7%) and in Lisbon (11.9%), with the remaining approved Demonstrators being spread across Alentejo (2.4%). Individual projects were deployed more scatteredly across the country, with 21.9% being centralized in Lisbon, 18.8% in the North, 6.3% in Alentejo and 3.1% in the Algarve[25] (*Figure 23*).

The value of the ***total eligible investment*** in the application for the SI R&D, in the instrument under analysis, added up to 35,102,509.2€. The incentive provided amounted to 19,471,879.8€, the equivalent to an ***average reimbursement rate*** of 55.5%[26].

In the individual Demonstrators typology, the Centre (55.6%), Lisbon (19.3%) and North (14.8%) congregated 89.7% of the total eligible investment and 88.2% of the support provided (55.4%, 16.1% and 16.7%, respectively).

Regarding co-promotion Demonstrators, the Centre (56.8%) and the North (29.7%), in turn, recorded the highest contribution in terms of investment (86.5%). It is moreover estimated that these regions were granted the highest support sum in absolute (11,864,309.2€) and relative (60.9% of the total sum) terms (*vide Figure 23*).

A reason behind the lower number of projects approved in the Lisbon region might be a budget allocation, featured in the opening notices, which is smaller for the projects belonging to the referred territory's Regional Operational Programme. Nevertheless, by analyzing the ***average value of the eligible investment per project,*** it quickly becomes apparent that the region of Lisbon was the second territory where – individual and co-promotion - Demonstrator projects of larger dimensions (330,739.8€ and 591,501.9€, respectively) converged, preceded by the Centre (416,379.7€ and 625,493.6€, respectively) (*Figure 22*).

Figure 22: Demonstrators per NUTS II regions

Source: Own design.

[25] *Figure 22* features the value, in absolute terms, of the Demonstrator projects according to NUTS II region.
[26] The values indicated are at current prices.

Figure 23: Number of SI R&D eligible applications, investment made and support provided, according to project typology and NUTS II regions (2015-2019)

Project typology	No. of eligibleApplications		Eligible investment (€)		Financial incentive (€)		Average reimbursement rate (%)
	N	% Total	€	% Total	€	% Total	% Total
Individual Demonstrator							
North	6	18.8%	1,772,936.6€	14.8%	1,027,135.7€	16.7%	57.9%
Centre	16	50.0%	6,662,075.9€	55.6%	3,400,600.1€	55.4%	51.0%
Lisbon	7	21.9%	2,315,178.9€	19.3%	984,648.6€	16.1%	42.5%
Alentejo	2	6.3%	879,679.3€	7.3%	546,452.9€	8.9%	62.1%
Algarve	1	3.1%	341,579.3€	2.9%	175,417.2€	2.9%	51.3%
Total of Individual Projects	**32**	**43.2%**	**11,971,450.1€**	**34.1%**	**6,134,254.4€**	**31.5%**	**51.2%**
Co-promotion Demonstrator							
North	15	35.7%	6,858,913.1€	29.7%	4,203,982.6€	31.5%	61,3%
Centre	21	50.0%	13,135,366.0€	56.8%	7,660,326.6€	57.4%	58,3%
Lisbon	5	11.9%	2,957,509.7€	12.8%	1,365,575.4€	10.2%	46,2%
Alentejo	1	2.4%	179,270.3€	0.76%	107,740.8€	0.81%	60,0%
Algarve	0	0.0%	0.0€	0.0%	0.0€	0.0%	0,0%
Total of Co-promotion Projects	**42**	**56.8%**	**23.131.059,1€**	**65.9%**	**13,337,625.8€**	**68.5%**	**57,7%**
Total	**74**	**100.0%**	**35,102,509.2€**	**100.0%**	**19,471,879.8€**	**100.0%**	**55.5%**

Source: Own design based on data extracted from ANI's SI R&D platform.

It matters now to understand whether statistical analysis shows significant differences in the *five dimensions of analysis*, per Demonstrator project typology, and in parallel, **whether technology cooperation, induced by co-promotion Demonstrators, in fact gives rise to more valuable projects, on a technical, technological and socio-economic levels.**

5.2. *Ex-ante* assessment

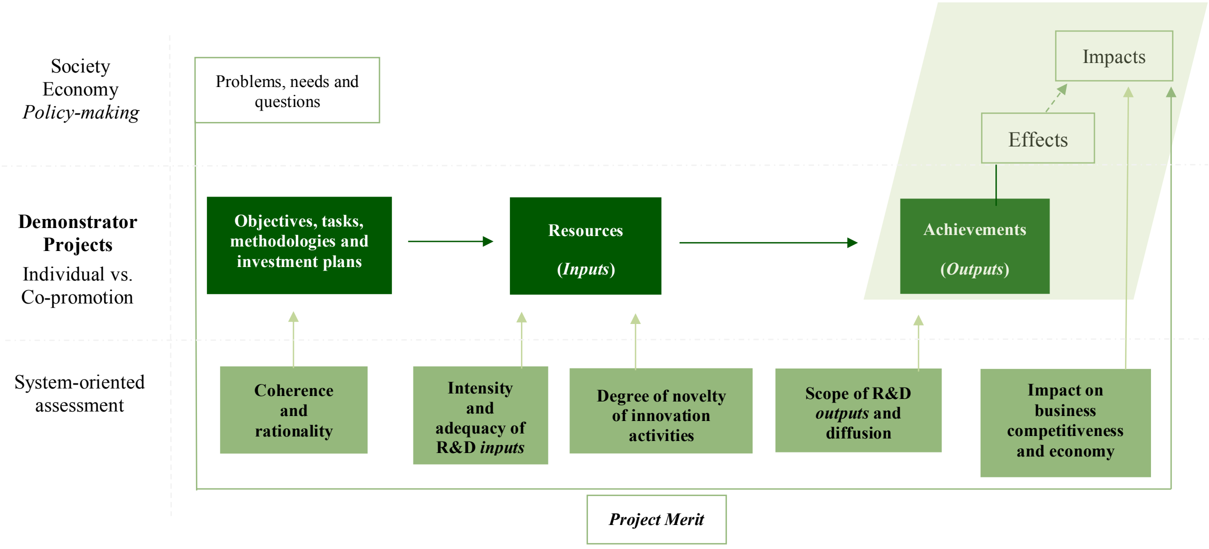
5.2.1. New merit referential

The main purpose of the *ex-ante* assessment was to analyze the **efficiency of the 74 Demonstrators** (*i.e.,* the technical connection between the established goals, their available *inputs*, the innovation that is to be developed, the envisaged *outputs* and their possible effects). Based on the *new merit referential*, a database was created, containing their performances in the *50 variables* under consideration[27]. The analysis relies on *inferential statistics*, in parametric and non-parametric tests, according to the nature of the variables, since the goal is to draw conclusions for the broad domain of the R&D incentive system and to attain generalizations applicable to analogous measures, which were not observed (Webster, 2006).

The assessment model is drafted in *figure 24*, below.

[27] The database built in *IBM SPSS version 24 encompasses* **3700 observations** for the execution of the *ex-ante* assessment.

Figure 24: Diagram of the assessment model applied to the Demonstrator projects



Source: Own design.

An empirical analysis of each dimension *per se* follows, for the purpose of testing the *five hypotheses* which steer the *ex-ante* assessment, and subsequently, a joint synthesis analysis is conducted.

5.2.2. Coherence and rationality[28]

The first dimension of analysis has a prominently technical nature, and it is governed by six selection criteria[29], which aim to assess the projects regarding the type of beneficiary company, the number of co-promoters, the sector of activity, the quality of the work-plan, the relevance of the techno-scientific methodology and the congruence of their investment plans in respect to the goals that were set. In this dimension, the lowest *rating* attained was of 1.5 points and the highest of 5.0 points. 50% of the projects scored, therefore, a maximum of 3.3 points.

5.2.2.1. Type of leading company

When assessing the ***type of leading company*** that invests in R&D, it was verified that co-promotion projects achieved an average *score* of 3.8 points (*Std. deviation* = 0.7), which indicates a relative dispersion. Within this typology, the most frequent category was leadership by a *"small-scale enterprise"* (38.1%). Conversely, individual projects

[28] *Coherence and rationality* is a quantitative variable that comprises values between 1 (*mediocre*) and 5 (*exceptional*), attained through the following formula $\overline{Dimention\ \iota} = 0.1\boldsymbol{i_1} + 0.2\boldsymbol{i_2} + 0.1\boldsymbol{i_3} + 0.2\boldsymbol{i_4} + 0.2\boldsymbol{i_5} + 0.2\boldsymbol{i_6}.\ (10)$

[29] *Cronbach's α* = 0.779, which means that there is internal consistency between the six selection criteria that constitute *coherence and rationality* (vide ***Appendix VII.I***).

reached a lower *score*, of 3.0 points, with a standard deviation of 0.9, which conveys the weight of the leadership of *"medium-scale enterprises"* (25.0%) and *"large-scale enterprises"* (21.9%).

According to the literature, this scenario was expectable, since small-scale companies are nearly always considered to be technology recipients and seldom the holder of resources or of their own expertise (Carayol, 2003; Doh and Kim, 2014; Heirman and Clarysse, 2004; Hölzl, 2008; Hu *et al.*, 2006).

Demonstrator projects will hence allow them to compensate for the regular under-investment in R&D and, above all, to increase their technological capacity for the creation of new or improved solutions (Scandura, 2016). On the other hand, large-scale enterprises own more internal funds and have more R&D capacity, being, therefore, able to develop a new technology *per se* (Kobarg *et al.*, 2019), by turning more often to individual Demonstrators.

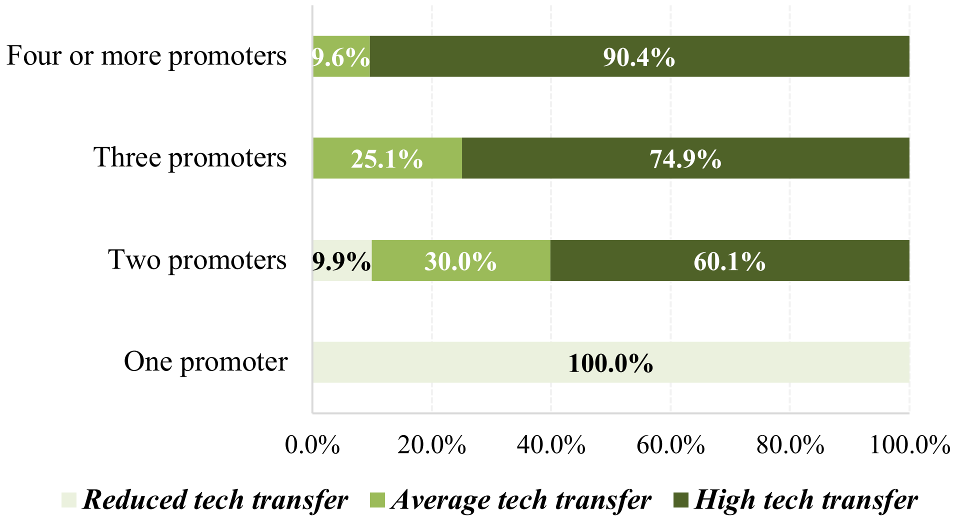
Nevertheless, despite the differences in ratings, when the hypothesis was tested of the existence of a connection between the type of leading company and the Demonstrator typology, it was determined that these dissimilarities are slight, the relation between the two elements being very faint and non-significant (Cramer's $V_{(74)} = 0.096$; *p-value* = 0.876).

5.2.2.2. Number of co-promoters

Regarding the ***number of co-promoters*** involved in the R&D project, it is important to emphasize that individual Demonstrators were represented by a single beneficiary, whereas co-promotion projects could present a consortium comprised of two organizations, either companies or scientific and technological entities. More precisely, it was observed that the former achieved an average *score* of 2.9 points, whilst the latter, represented predominantly by *two promoters* (47.6%), reached an average score of 3.7 points.

As demonstrated in *figure 25*, the larger the co-promoters' *network*, the more intense is the transfer flow of technological knowledge. Given the fact that most of the co-promotion projects were represented by two promoters, it was possible to establish the still early representation of innovation as a *knowledge-intensive process* which entails a collective effort and extensive partnerships in collaboration *networks* with different entities in the system.

Figure 25: Number of co-promoters, according to intensity of technology transfer (2015-2019)



Source: Own design based on the data processed in SPSS.

5.2.2.3. Sector of activity

The ***sector of activity*** in which the innovative solution is set to be implemented also differed between the two types of Demonstrators, albeit in a non-significant way (Cramer's V $_{(74)}$ = 0.195; *p-value* = 0.107).

It is indeed interesting to observe that, even though the *"service sector"* is associated with more technologically advanced fields (*e.g.* telecommunications, the development of software or ICT) (Romijn and Albaladejo, 2002) and its frequency has been higher in individual projects (62.5%), it turned out to have a lower assessment (2.9 points), in comparison with the *"industrial sector"* (3.0 points) and, above all, with the co-promotion Demonstrators which had 57.1% of the projects in the industrial sector (3.7 points). This might be due to the convergence, regarding R&D intensity, in the two sectors of activity, which is increasingly visible owing to the rise of *knowledge economies* (Cucculelli and Ermini, 2012).

5.2.2.4. Work plan and S&T methodology

Focusing on more technical and scientific aspects, the congruence of the designed ***work plan*** was assessed, particularly the adequacy of the tasks, regarding its description, duration and participants.

With regard to individual Demonstrators, it was ascertained that 34.4% of the projects delivered a "*very-well devised*" work plan, with tasks logically and iteratively chained, well outlined techno-scientific goals, activities which are duly interconnected and very well distributed across the 18 months. Conversely, 15.6% of the projects reveal "*some deficiencies*", aiming, from the outset, to partially meet the scientific and commercial challenges faced by the designed technology (2.8 points).

It was possible to ascertain that co-promotion Demonstrators displayed a considerably higher *score* (3.4 points), particularly owing to shared responsibilities and to the exchange of resources and *skills* between business technical staffs and researchers, minimizing, thereby, the risk of breaching the schedule, as well as established goals and targets (Cramer's $V_{(74)} = 0.173$; *p-value* = 0.546) (*Figure 26*).

Subsequently the technical quality of the ***technological and scientific methodology*** designed for the completion of the innovation was assessed. Both individual Demonstrators and co-promotion ones thrived on the excellence and technical accuracy of the methodologies in more than 60.0% of the projects. Yet, 5.0%-10.0% displayed weak and dubious descriptions, which added up to an average *score* of 2.6 and 3.5, respectively (*Figure 26*).

Figure 26: Work plan and S&T methodology, per project typology (2015-2019)

Criteria	*Individual Demonstrator*		*Co-promotion Demonstrator*		Total	
	N	% Total	N	% Total	N	% Total
Work plan						
Weak	0	0.0%	0	0.0%	0	0.0%
With some deficiencies	5	**15.6%**	4	9.5%	9	12.2%
Averagely devised	10	31.2%	11	26.2%	21	28.4%
Well-devised	6	18.8%	14	**33.3%**	20	27.0%
Very-well devised	11	**34.4%**	13	31.0%	24	32.4%
S&T methodology						
Weak description	1	3.1%	0	0.0%	1	1.4%
Defective description	3	9.4%	2	4.8%	5	**6.8%**
Average description	10	31.3%	12	28.6%	22	29.7%
Good description	13	**40.6%**	16	**38.1%**	29	**39.2%**
Excellent description	5	15.6%	12	28.6%	17	**22.9%**

Source: Own design based on the data processed in SPSS.

5.2.2.5. Financial resources

Finally, the pertinence of the ***financial resources*** was assessed, and slight differences became noticeable when comparing the two typologies. Whilst in the case of individual projects, the plans were often placed in the *"reasonable budget"* assessment category, as being in need of some corrections and better balancing of the cost structure (46.9%), investment plans for co-promotion projects were predominantly considered to be *"sustained",* in need only of *minor* adjustments (40.5%) (*Figure 27*).

Figure 27: Investment plan, according to project typology (2015-2019)

Criteria	*Individual Demonstrator*		*Co-promotion Demonstrator*		Total	
	N	% Total	N	% Total	N	% Total
Investment plan						
Insufficient resources	0	0.0%	0	0.0%	0	0.0%
Uneven resources	2	6.3%	2	4.8%	4	5.4%
Reasonable budget	15	**46.9%**	13	31.0%	28	37.8%
Sustained budget	5	15.6%	17	**40.5%**	22	29.7%
Balanced and rightly sustained budget	10	31.3%	10	23.8%	20	27.0%

Source: Own design based on the data processed in SPSS.

It is possible to draw from these data that science-industry cooperation has allowed investors a more balanced understanding (and estimation) of the possible expenses at each step and activity of the process of technology development, albeit still in a mild, non-significant way (Cramer's $V_{(74)} = 0.271$; $p\text{-}value = 0.158$).

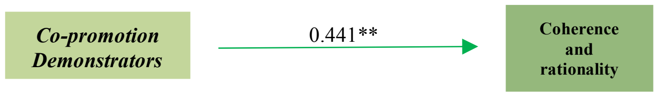
5.2.2.6. Summary analysis of the *coherence and rationality dimension*

Having tested the hypothesis that collaborative R&D and technology transfer give rise to projects with better technical and financial performances, statistical significance was found to assert that the **assessment** in this dimension **is different between the two typologies** ($F_{(1;72)} = 17.369$; $p\text{-}value = 0.000$)[30]. In fact, co-promotion Demonstrator projects displayed, on average, substantially higher performance, regarding its *coherence*

[30] Test *one-way ANOVA* was applied (*vide* ***Appendix VII.II***).

and rationality (3.6 against 2.9 points), knowing that the closer the innovation projects stands to the 5.0 mark, the more coherent it will be[31].

Having determined the influence of project typology on *coherence and rationality*, the aim was to understand the intensity of the association between these two variables. It was ascertained that there is a *moderate dependency* relationship (*Eta* = 0.441; *p-value*= 0.000).



** Dependency relationship is significant at the 0.01 level.
Source: Own design based on the data processed in SPSS.

5.2.3. Intensity and adequacy of R&D *inputs*[32]

This dimension aims to assess the intensity of R&D, regarding new appointments for the beneficiary company, including PhD holders, team suitability and qualification, and the organizational *network* established for the development of the innovation[33]. The lowest *score* was assigned to an individual Demonstrator (1.2 points) and the highest to a co-promotion project (5.0). Half the Demonstrator projects scored a maximum of 3.0 points.

5.2.3.1. Parties involved

Firstly, it was ascertained which ***parties were involved*** in the project, with interdisciplinary collaboration between companies and technology infrastructures being appraised (Arora and Gambardella, 2001; Bozeman, 2000). In this regard, it was clear that co-promotion Demonstrators were at an advantage from the outset, with the most frequent *consortium* being established between business organizations and universities/polytechnic institutes (38.1%), which allowed them to reach an average *score* of 3.6 points.

Statistically, significance was found to argue that there is a strong relation between project typology and the *parties involved* (Cramer's $V_{(74)} = 0.897$; *p-value* = 0.000). It is, therefore, relevant to highlight that this type of *academia-industry* connection presents

[31] H_1 confirmed.
[32] *Intensity and adequacy of R&D inputs* is a quantitative variable which encompasses values between 1 (*mediocre*) and 5 (*exceptional*), attained through the following formula $\overline{Dimention\ ii} = 0.2ii_1 + 0.2ii_2 + 0.1ii_3 + 0.1ii_4 + 0.2ii_5 + 0.2ii_6.$ (11)
[33] *Cronbach's* $\alpha = 0.751$, which means that there is internal consistence between the six selection criteria which comprise *intensity and adequacy of R&D inputs* (*vide* ***Appendix VII.I***).

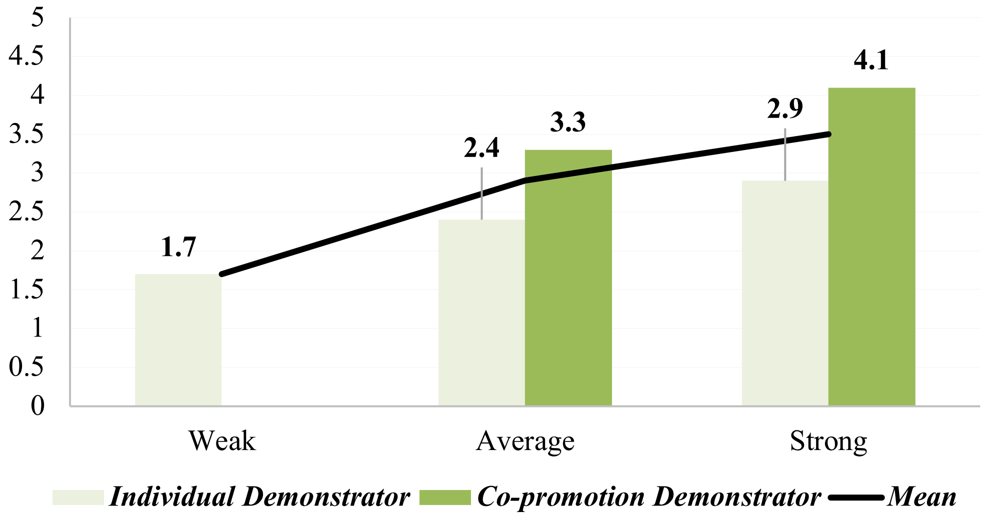
several benefits for companies, since universities are constantly developing studies concerning technologies that have been recently introduced in the market, which allows for direct contact with the scholars who devised and built those same solutions (Amesse and Cohendet, 2001).

5.2.3.2. Team's expertise

Regarding ***team's expertise***, it was ascertained that, in both typologies, teams with moderate scientific and technical knowledge in *key-fields* were allocated to the projects, the equivalent of 40.0% of professionals with a degree corresponding to *ISCED* 6. However, it is worth noting that 15.6% of individual Demonstrators allocated to their projects professionals who have an education level lower than *ISCED 6*, in fields encompassing tasks which demand more specialized intellectual knowledge than what is made available (1.7 points).

This situation did not occur with co-promotion Demonstrators, thereby providing statistical evidence to assert that ***team's expertise*** is *moderately influenced* by project typology (Cramer's V $_{(74)}$ = 0.349; *p-value* = 0.009) (*Figure 28).*

Figure 28: Distribution of the team's expertise criterion, according to project typology (2015-2019)

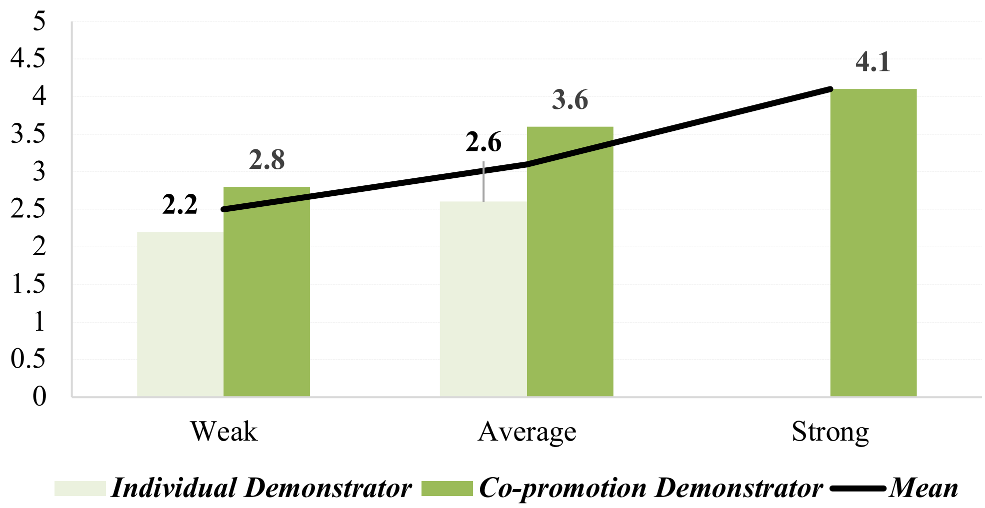


Source: Own design based on data processed in SPSS.

5.2.3.3. Team's adequacy and the need to subcontract external services

It should be emphasized that in the ***team's adequacy*** criterion, much stronger and significant differences were registered (Cramer's V $_{(74)}$ = 0.757; *p-value* = 0.000), as can be observed in *figure 29*, below. Whereas most co-promotion projects displayed a *"moderately experienced, specialized and multidisciplinary team"*, individual Demonstrators, on average, introduced *"human resources with no past experience in R&D, with little preparation as well as poor coordination"*, and having no prior definition of *tasks* for each technician.

Figure 29: Average rating of the team's adequacy criterion, according to project typology



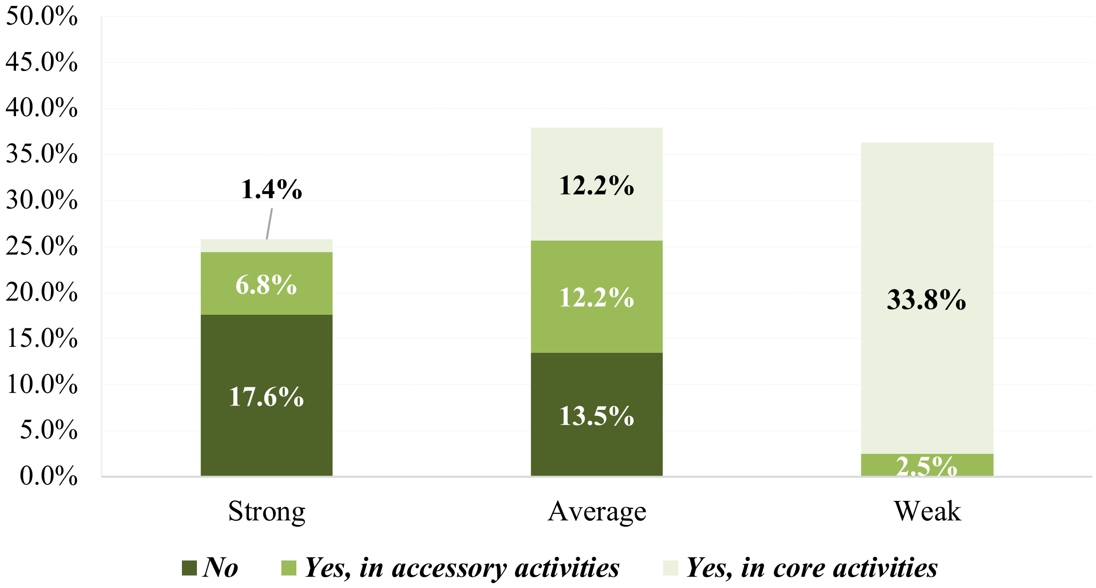
Source: Own design based on data processed in SPSS.

Individual Demonstrators hence showed a greater ***need to subcontract*** professionals external to the team (90.7%), with special emphasis on subcontracting for projects' *core* activities (84.4%). This was not the case with co-promotion projects, which stood out for not requiring external services (47.7%), and when in actual need, for contracting only in ancillary activities (33.3%), which made it possible for them to be assessed more firmly, with 3.5 points (Cramer's V $_{(74)}$ = 0.648; *p-value* = 0.000).

With the purpose of ascertaining whether the ***suitability of the team*** influenced the need to subcontract external professionals, regardless of project typology, the *Chi-square test of independence* was conducted, which disclosed the existence of a connection between the two criteria ($x^2_{(4)}$ = 41.428; *p-value* = 0.000). A relatively strong relation between them was observed (Cramer's V $_{(74)}$ = 0.748; *p-value* = 0.000).

As expected, a weak suitability of the team brought about the need to subcontract technicians outside the projects (33.8%). Conversely, when relying upon a strong and appropriate team, only 1.4% of projects required external contracting (*Figure 30*).

Figure 30: Distribution of the need to subcontract activities criterion according to the suitability of the team (2015-2019)



Source: Own design based on data processed in SPSS.

5.2.3.4. Reinforcement of R&D capacity regarding new appointments

The expansion of *companies' technical teams*[34] pertaining to R&D activities, by hiring more qualified technicians, should also be stressed. New appointments enabled teams to execute technology projects and, consequently, to mitigate possible risks associated with the planned activities (*e.g.* technology risk, commercial risk and/or cultural risk).

This situation was quite noticeable, since in both typologies, more than 55.0% of projects fostered the creation of *"highly qualified jobs"*. Yet, no statistical evidence was found to support the idea that the *reinforcement of R&D capacity* was influenced by project typology (Cramer's V $_{(74)}$ = 0.091; *p-value* = 0.801), since the distributions were very similar.

[34] *C Index* = $\frac{Number\ of\ people_{month}\ with\ ISCED\ level\ 6\ or\ higher\ to\ recruit\ for\ the\ project\ for\ R\&D\ activities}{Number\ of\ people_{month}\ allocated\ to\ the\ project}$ x 100. *(12)*

The assessment of the project's impact on the reinforcement of R&D skills was accompanied by the endeavor to ascertain the particular effect of hiring PhD holders for their teams. The ascertainment of the ***effect of the PhD holders' participation*** is provided by:

$$D\ Index = \frac{Number\ of\ people_{month}\ with\ ISCED\ level\ 8\ allocated\ to\ the\ project}{Number\ of\ people_{month}\ allocated\ to\ the\ project}\ x\ 100. \qquad (13)$$

It was quickly determined that the impact was quite significant (67.6%), albeit stronger in the category of co-promotion Demonstrators, considering that 40.5% of the technicians allocated to their projects had a degree corresponding to *ISCED 8* (*Figure 31*).

Figure 31: Engagement of PhD holders, according to project typology (2015-2019)

Criteria	*Individual Demonstrator*		*Co-promotion Demonstrator*		Total	
	N	% Total	N	% Total	N	% Total
Engagement of PhD holders						
Low (D *Index* ≤ 5.0%)	13	40.6%	11	26.2%	24	32.4%
Average (5.0% < *D Index* ≤ 20.0%)	12	37.5%	14	33.3%	26	35.2%
High *(D Index* > 20.0%)	7	21.9%	17	**40.5%**	24	32.4%

Source: Own design based on data processed in SPSS.

This scenario was clearly expected, given the fact that, in co-promotion projects, there is a direct connection between researchers from R&D centers (*i.e.,* professionals who have a degree equal to or higher than *ISCED* 7) (Carayol, 2003). It was thus observed that the larger the collaborative *network* was on a project, the bigger was the number of PhD holders being hired.

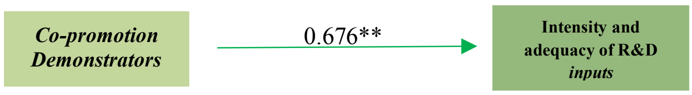
5.2.3.5. Summary analysis of the *intensity and adequacy of R&D inputs* dimension

In short, having tested the hypothesis that collaborative R&D leads to technologies which are developed by more competent and adequate human resources, it was ascertained that there is, in fact, statistical evidence to argue that **performance** in the *intensity and adequacy of R&D inputs* dimension **is different in the two types of Demonstrator** ($F_{(1;72)} = 60.598$; *p-value* = 0.000)[35].

[35] The *one-way ANOVA* test was applied (*vide* ***Appendix VII.III***).

Co-promotion Demonstrator projects attained, on average, a considerably higher *score* than the others (3.6 against 2.4). It should be borne in mind that the closer they stand to the 5.0 mark, the more skilled and suitable will the project members be.

Having determined the influence of the project typology factor on *intensity and adequacy of R&D inputs,* the intensity of the association was measured. It was ascertained that there was a relation of *moderate-strong dependence* (*Eta* = 0.676; *p-value* = 0.000), which comes to prove that, the more intense the knowledge transfer is between investors, the more suitable are the R&D *inputs*, for the successful achievement of technological innovation[36].



** Dependency relationship is significant at the 0.01 level.

Source: Own design based on the data processed in SPSS.

5.2.4. Degree of novelty of innovation activities[37]

The third dimension specifically addresses the topic of innovation, in conformity with six selection criteria[38] which aim to assess the proposed solutions regarding type, class and innovative nature, field and technological intensity and its degree of complexity. It was ascertained that the minimum *score* that was granted corresponded to 2.2 and the maximum to 5.0 points, wherefore 50.0% of the projects were, at most, rated at 3.8 points.

5.2.4.1. Type of innovation

Having analyzed the ***type of innovation*** criterion**,** it was attested that around 46.0% of the Demonstrators set about to develop a solution based on *"process innovation"*, with its main goal exceeding the changes in equipment and encompassing, additionally, production and work organization, which are historically interwoven with technical changes (Kovács, 2000). This is followed, in percentage, by the *"product innovation"* category (33.8%), which targeted the development or improvement of certain product features, for the purpose of creating competitive advantage through differentiation (Dosi, 1988) (*Figure 32*).

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[36] H_2 confirmed.

[37] *Degree of novelty of innovation activities* is a quantitative variable which encompasses values between 1 (*mediocre*) and 5 (*exceptional*), attained through the following formula $\overline{Dimention\ \boldsymbol{iii}} = 0.1\boldsymbol{iii}_1 + 0.1\boldsymbol{iii}_2 + 0.2\boldsymbol{iii}_3 + 0.1\boldsymbol{iii}_4 + 0.3\boldsymbol{iii}_5 + 0.2\boldsymbol{iii}_6$. *(14)*

[38] *Cronbach's* $\alpha = 0.831$, which means that there is internal consistency between the six selection criteria that constitute the *degree of novelty of innovation activities* (*vide* ***Appendix VII.I***).

When testing the hypothesis that a connection exists between project typology and the criterion under analysis, it was ascertained that there is no statistical evidence to argue that the type of Demonstrator influences the *type of innovation* (Cramer's $V_{(74)} = 0.202$; *p-value* = 0.232). Concurrently, equal *scores* were attained, which resulted in an average *score* of 3.7 points for both.

Figure 32: Type of innovation, according to project typology (2015-2019)

Criteria	*Individual Demonstrator*		*Co-promotion Demonstrator*		Total	
	N	% Total	N	% Total	N	% Total
Type of innovation						
Product innovation	8	25.0%	17	40.5%	25	**33.8%**
Process innovation	15	46.9%	19	45.2%	34	**45.9%**
Organizational innovation (technology-based)	9	28.1%	6	14.3%	15	20.3%

Source: Own design based on data processed in SPSS.

5.2.4.2. Class of innovation

By moving the ***innovation referential to a macro level***, two main levels are contemplated. With respect to individual projects, 59.4% of the Demonstrators set about to develop solutions which *"slightly differed from the ones already existing in the market"*, through small changes that brought about the improvement of their quality or cost reduction, resulting from technology assimilation, the achievement of compatibility between different pieces of equipment and the process of interaction with providers (*i.e.*, *"incremental innovation"*). This occurrence granted them an average *score* of 3.8 points.

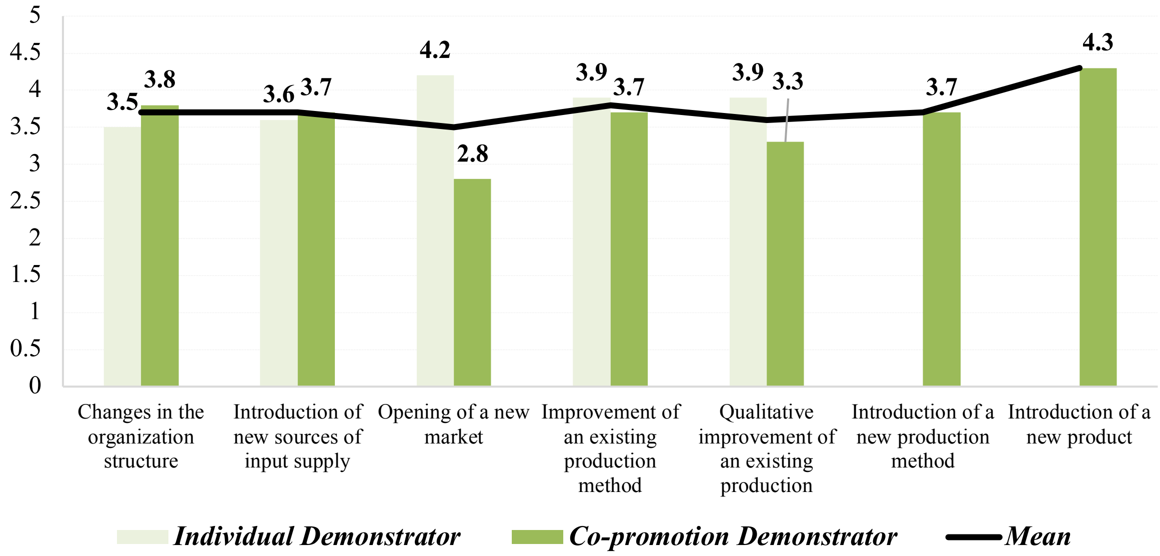
On the other hand, the vast majority of co-promotion Demonstrators (59.4%) set about to develop innovations that entail *"discontinued processes"*, which arise from formal R&D efforts in companies' labs or in cooperation with technological entities, for the purpose of *"reaching a totally new market"* (*i.e., "radical innovation"*). Nevertheless, their visionary character granted them an average rating that is equal to the others, of 3.8 points. This scenario matches the similarity in the distributions between typologies, which suggests that there is no group influence on the class of innovation (Cramer's $V_{(74)} = 0.187$; *p-value* = 0.159).

5.2.4.3. Nature of the innovation

Regarding the ***nature of the innovation***, some dissimilarity can be found. In individual Demonstrators, the most frequent category was the *"introduction of new sources of input supply"* (40.6%), whereas co-promotion Demonstrators stood out in the *"introduction of a new product"* category (26.2%).

Furthermore, it was ascertained that project typology does, in fact, have influence on the *nature of the innovation* (Cramer's V $_{(74)}$ = 0.412; *p-value* = 0.043). It is interesting to observe, in *figure 33,* that no individual Demonstrator set about to develop a new production method or a new product, which are innovations that entail more technological disruption.

Figure 33: Average score of the nature of innovation criterion, according to project typology

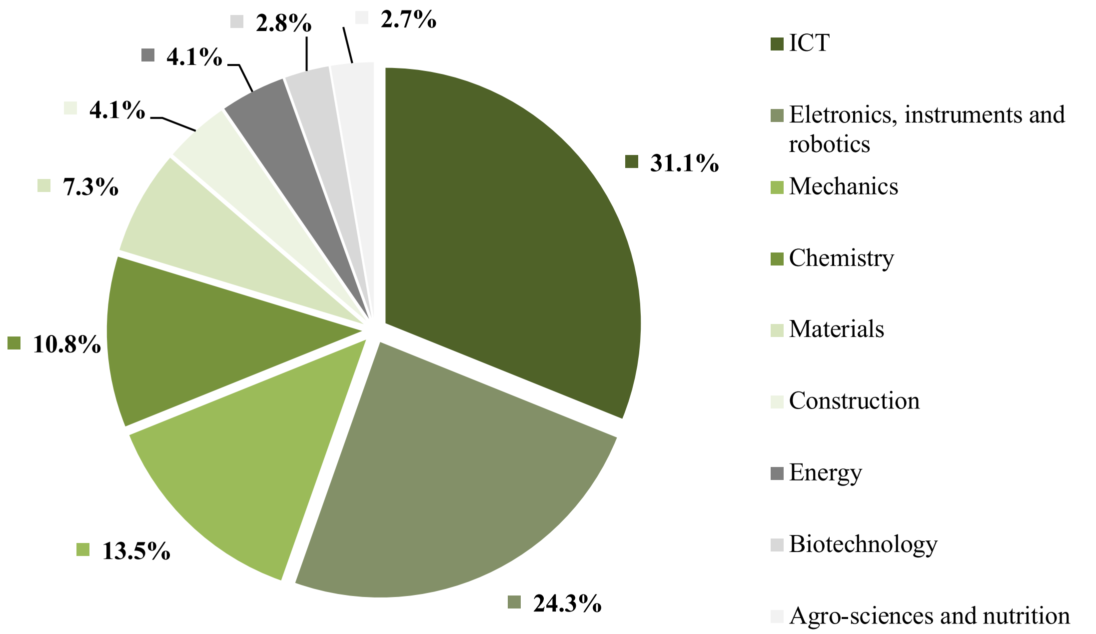


Source: Own design based on data processed in SPSS.

5.2.4.4. Technological field, R&D intensity and degree of technological complexity

Most projects strived to implement a new solution in the field of *ICT, instruments and robotics* (55.4%), followed by the *mechanics and energy* (13.5%) and *chemistry* (10.8%) categories (*Figure 34*). Since there is no association between this criterion and the type of Demonstrator (Cramer's V $_{(74)}$ = 0.316; *p-value* = 0.120), a similar average *score* of 3.5 points for both typologies was observed.

Figure 34: Technological fields developed by the Demonstrator projects (2015-2019)



Source: Own design based on data processed in SPSS.

In line with the aforementioned, it was possible to ascertain that most of the projects in question stem from industries with *"high-intensity technology"* (55.4%) and *"high degree of complexity"* (54.1%) (Cramer's $V_{(74)} = 0.206$; *p-value* = 0.230). In reality, it was possible to determine that 55.4% of leading companies displayed R&D intensity higher than 5.0%, against 5.5% of beneficiary companies that poorly performed, with an investment in R&D between 0.0%-1.0%, measured in production volume.

5.2.4.5. Summary analysis of the *degree of novelty of innovation activities dimension*

When testing whether collaborative R&D leads to projects with innovation proposals with a higher degree of novelty, it was determined that there is no statistical evidence to indicate that, on average, performance in the *degree of novelty of innovation activities* dimension differs between co-promotion and individual projects[39]. It was verified that **their average *ratings* are similar**, of approximately 3.8 points ($F_{(1;72)} = 0.032$; *p-value* = 0.859)[40].

[39]The *one-way ANOVA test* was applied (*vide* ***Appendix VII.IV***).
[40] H_3 refuted.

5.2.5. Scope of innovation *outputs* and diffusion[41]

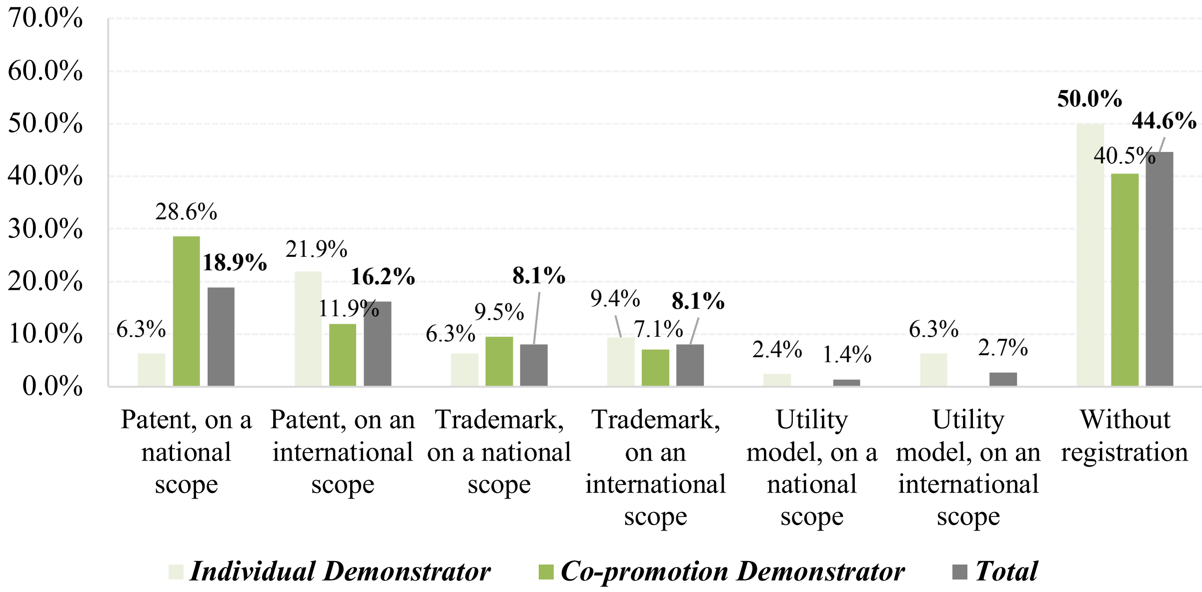
The fourth dimension pertains to the innovation *outputs* and it is governed by six selection criteria[42], which assess intellectual property (IP) registration or application for registration, possible externalities generated, as well as the effects of dissemination and valuation of results. The minimum *score* granted was of 0.9 points and the maximum of 4.4 points, wherefore 50.0% of projects were, at most, rated 3.0 points.

5.2.5.1. Intellectual property registration and the type of protection

For a significance level of 5.0%, it was ascertained that there is no statistical evidence to support the idea that project typology influences the existence of (an application for) IP registration ($x^2_{(2)} = 0.781$; *p-value* = 0.692)[43]. It was, however, observed that its affluence was higher in the category of co-promotion projects (50.0%), among which 7.1% claimed to have more than one registration.

Having specifically analyzed the ***type of protection*** required, it was observed that, in both typologies, *patenting* was the most popular choice (35.1%), followed by *trademark* registration (16.2%). However, around 45.0% of the projects did not have any kind of protection, among which $\frac{1}{2}$ were individual Demonstrators (*Figure 35*).

Figure 35: Type of protection, according to project typology



Source: Own design based on data processed in SPSS.

[41] *Scope of R&D outputs and diffusion* is a quantitative variable which encompasses values between 1 (*mediocre*) and 5 (*exceptional*), attained through the following formula $\overline{Dimention\ iv} = 0.1iv_1 + 0.1iv_2 + 0.1iv_3 + 0.2iv_4 + 0.2iv_5 + 0.3iv_6$. (15)

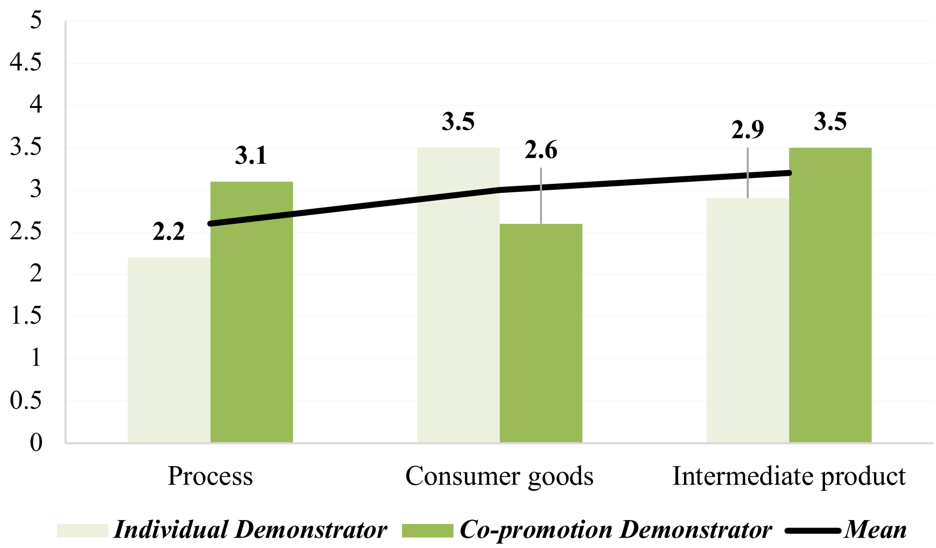
[42] *Cronbach's* $\alpha = 0.793$, which means that there is internal consistency between the six selection criteria that constitute the *scope of R&D outputs and diffusion* (*vide **Appendix VII.I***).

[43] The *Chi-square* test of independence was applied.

5.2.5.2. Positive externalities

Regarding the expected project's capacity to generate ***positive externalities for the economy***, the creation of intermediate products and services aimed specially at companies was valued. It was considered a process when the technology taker (*i.e.,* the company) did not participate in the capacity of the project leader, as long as that feature was clearly stated in the consortium agreement. In order to ascertain whether collaborative R&D influences the creation of *positive externalities*, the test of independence was conducted, revealing that there is no connection between the two variables ($x^2_{(2)} = 2.608$; *p-value* = 0.283). Therefore, contrary to what was expected, it was verified that co-promotion projects do not provide more positive externalities for national economy, with very similar *ratings* being attained for the two typologies (*Figure 36*).

Figure 36: Average ratings of the positive externalities' criterion, according to project typology



Source: Own design based on data processed in SPSS.

5.2.5.3. Effects of dissemination and economic valorization of results

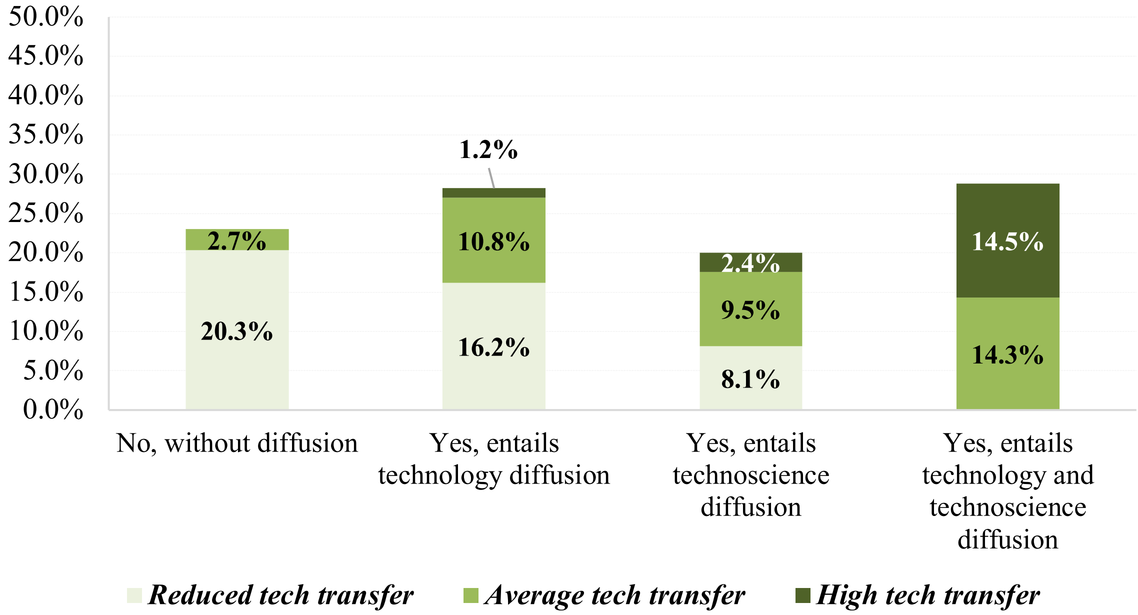
When analyzing the management of the acquired knowledge and its subsequent effects regarding the ***dissemination and diffusion of results*** in the business world, it was discerned that 43.2% of the Demonstrator projects envisaged, in the application, the *"technological and techno-scientific diffusion of results"*. In this regard, only 8.1% of the projects expressed disinterest in the economic valuation of their *outputs*, through *"action plans lacking in coherence"*.

It should be noted that co-promotion Demonstrator projects were the ones that with their high intensity of technology transfer (18.6%) allowing them to achieve substantially higher *ratings* (3.6 against 2.1 points).

By observing *figure 37,* it is easy to conclude that the higher the intensity of technology transfer, the lower is the number of projects which depreciate technology diffusion. It was also possible to verify that 20.3% of the Demonstrators that showed no interest in disseminating and valuing knowledge exhibited low transfer flows.

It was, thus, possible to ascertain the pertinence of technology transfer for the diffusion and valuation of R&D results in the corporate world.

Figure 37: Type of technological diffusion, according to technology transfer intensity



Source: Own design based on data processed in SPSS.

5.2.5.4. Summary analysis of the *scope of R&D outputs and diffusion* dimension

Having tested the hypothesis that collaborative R&D leads to projects that envisage greater effects of technology dissemination and promotion in the market among potential clients, it was determined that statistical evidence actually exists to support the argument that **performance** in the *scope of R&D outputs and diffusion* dimension **is higher in co-promotion projects** ($F_{(1;\,72)} = 6.519$; *p-value* = 0.013)[44].

[44]The *one-way ANOVA test* was applied (*vide* ***Appendix VII.V***).

Along with this conclusion, it was ascertained that there is a *weak-moderate* relationship between project typology and the dimension in question (*Eta* = 0.288). Nevertheless, even though co-promotion projects produce more effects of dissemination and valuation of R&D results, they are not likelier to produce more externalities for the economy.

5.2.6. Impact on business competitiveness and economy[45]

The fifth dimension of analysis is governed by six selection criteria[46], which aim to assess the impact of innovation on the micro and macroeconomic level, as well as its effect on regional and sectorial convergence, according to *Portugal 2020's priorities*.

It was observed that the lowest *score* was of 2.1 points and the highest one of 5.0, wherefore half the projects were, at maximum, rated 4.1. This was, therefore, the best-performing dimension on the *ex-ante* assessment.

5.2.6.1. Business strategy and the propensity for international markets

The importance of the projects for the ***leading company's strategy*** was assessed, thereby determining that 44.6% strived to *"expand their business, by supplying new customer segments and new markets"*, particularly co-promotion Demonstrators (29.7%). Individual projects strived mainly to *"expand their current business, by improving the efficiency of their processes"* (43.8%).

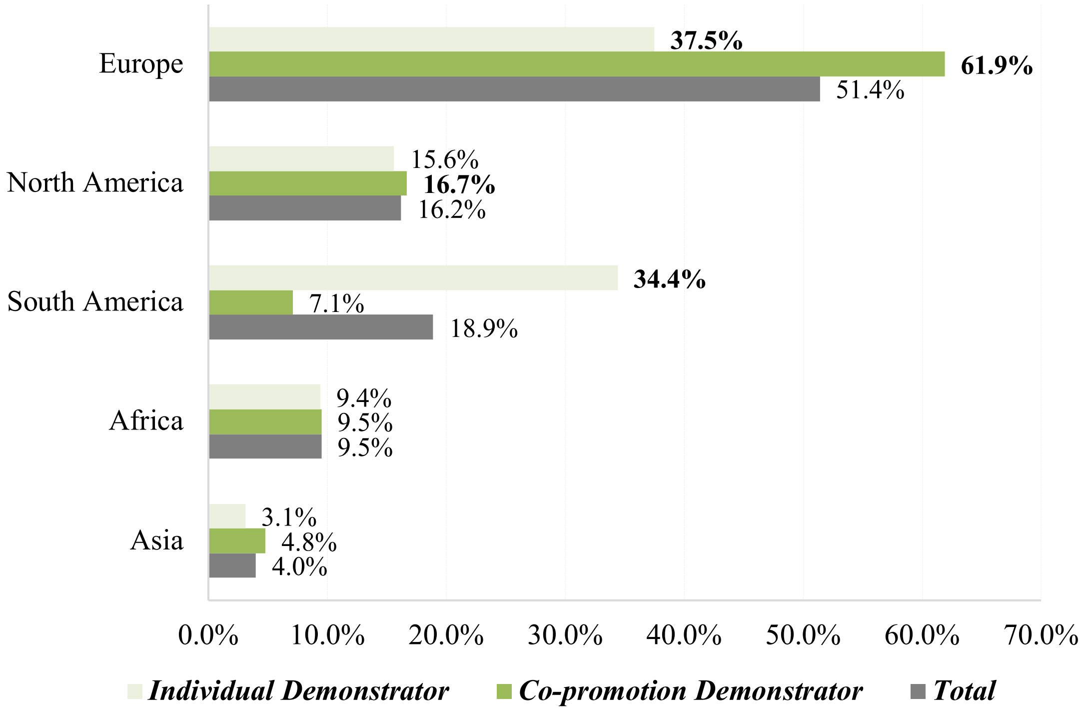
When assessing the role played by the projects in increasing the ***promoters' international competitiveness***, it was ascertained that only 14.9% of the beneficiary companies *"did not have established export channels"*, among which 9.5% were individual Demonstrators. Moreover, it was determined that among the 85.1% that were exportable, 47.3% showed, in their application proposals, their *"involvement with agents that facilitate the access to international markets"* and that are relevant for the companies' strategic guidelines.

Nonetheless, no evidence was found to support the idea that project typology influences the company's strategy (Cramer's V $_{(74)}$ = 0.243; *p-value* = 0.110), even though co-promotion projects have proven to be more ambitious in establishing external connections, particularly with Europe (61.9%) and North America (16.7%) (*Figure 38*).

[45] *Impact on business competitiveness and economy* is a quantitative variable which encompasses values between 1 (*mediocre*) and 5 (*exceptional*), attained through the following formula $\overline{Dimention\ \boldsymbol{v}} = 0.2\boldsymbol{v}_1 + 0.1\boldsymbol{v}_2 + 0.1\boldsymbol{v}_3 + 0.2\boldsymbol{v}_4 + 0.2\boldsymbol{v}_5 + 0.2\boldsymbol{v}_6.$ *(16).*

[46] *Cronbach's* α = 0.761, which means that there is internal consistency between the six selection criteria that constitute *impact on business competitiveness and economy* (*vide* ***Appendix VII.I***).

Figure 38: Target-market, according to project typology



Source: Own design based on data processed in SPSS.

5.2.6.2. Contribution to national economy

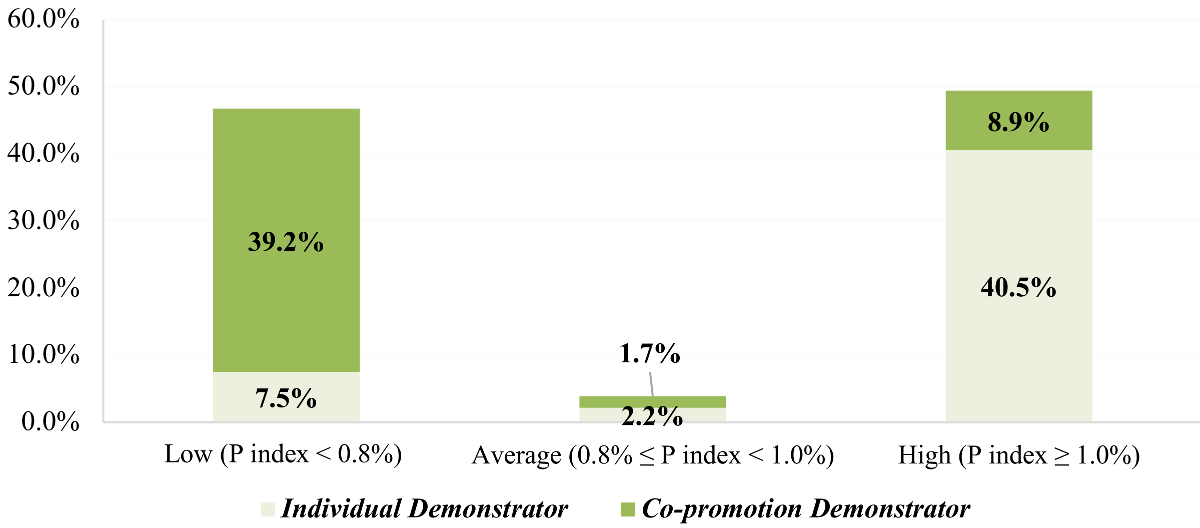
62.2% of the Demonstrator projects envisaged, in their application, a high ***contribution to national economy***, against 12.2% which predicted that the final result of the productive activity would be a small difference between the production value and the value of the intermediate product (*i.e.,* a *low* GVA).

The post-project investment on R&D is attained through:

$$P\ Index = \frac{post-project\ beneficiary\ investment\ on\ R\&D}{post-project\ beneficary\ VAB} \text{x } 100. \qquad (17)$$

Upon testing whether there is dependence between the type of project and the envisioning of *R&D expenses in the post-project*, a moderate and significant relationship was observed (*Eta* = 0.461). Contrary to what was expected, individual projects stood out, revealing, on average, an *index P* equal to 2.0%. Conversely, 47.6% of co-promotion projects foresaw a post-project investment on R&D lower than 0.8% (*Figure 39*). This means that, following the projects' completion, individual projects will probably be the ones investing the most in R&D on the national level.

Figure 39: Post-project investment in R&D according to project typology (2015-2019)



Source: Own design based on data processed in SPSS.

5.2.6.3. Contribution to ENEI

This was followed by the analysis of the Demonstrators' contribution to the national strategy of smart specialization, in force within the scope of the current Support Framework. This criterion aims to assess ***the projects' integration in Portugal 2020's priority domains,*** establishing that a *strong project* is integrated in *three or more domains*, whilst a *weak project* is integrated in *only one*.

Overall, most Demonstrators exhibited a moderate integration (44.6%), in other words, they embodied two specialization domains. However, differences between typologies were discernible, albeit non-significant ($x^2_{(2)} = 2.582$; *p-value* = 0.286).

It bears mentioning that 50.0% of the individual projects focused on only two domains, whereas co-promotion Demonstrators were more scattered, with 35.7% of their projects integrated in three or more thematic domains.

Through a synthesis of the national and regional diagnoses pertaining to the economic sectors which are, or might become, competitive, *five thematic units*[47] were built which share common and primary ideas for Portugal.

Among these, 32.8% of the Demonstrators are integrated in the second thematic unit *"Production industries and technologies"*, particularly in the development of production technologies and process industries (23.1%). Its purpose was the fostering of sustainable industrial growth, predicated on high-added value products and technological

[47] *Vide* Appendix I.

content (*i.e.,* factories of the future). 24.6% of the companies developed projects in connection with the first thematic unit *"Transversal technologies and their applications"*, among which 17.2% were related to the field of ICT (*i.e.,* the fostering of electronic infrastructures, software modeling and simulation or new digital business models), and 5.2% to the field of energy (*i.e.,* production optimization, energy transport and energy efficiency). On the other hand, only 7.5% of the projects pertained to the *"Mobility, space and logistics*" unit, neglecting topics such as green chemistry and the rise in competitiveness of the pharmaceutical industry (*Figure 40*).

It is worth mentioning that the units which intertwined the most as priorities of the Demonstrator projects, were the first, "*Transversal technologies and their applications*", and the second, "*Production industries and technologies*" (67.6%), followed by a combination between the first, *"Transversal technologies and their applications"* and the fourth, *"Natural resources and environment"* (24.5%).

Figure 40: Integration of the Demonstrators within the thematic units of Portugal 2020 (2015-2019)

	Thematic units of Portugal 2020	**Individual Demonstrator**		**Co-promotion Demonstrator**		**Total**	
		N	% Total	N	% Total	N	% Total
	Transversal technologies and their application						
	Energy	1	1.7%	6	7.9%	7	**5.2%**
	ICT	12	21.1%	11	14.2%	23	**17.2%**
	Raw materials	2	3.5%	1	1.3%	3	2.2%
67.6%	**Total**	**15**	**26.3%**	**18**	**23.4%**	**33**	**24.6%**
	Product industries and technologies						
	Production technologies and product industries	4	7.0%	9	11.7%	13	9.7%
	Production technologies and process industries	16	28.1%	15	19.5%	31	**23.1%**
24.5%	**Total**	**20**	**35.1%**	**24**	**31.2%**	**44**	**32.8%**
	Mobility, space and logistics						
	Automobile, aeronautics and space	5	8.8%	2	2.6%	7	**5.2%**
3.8%	Transports, mobility and logistics	2	3.5%	1	1.3%	3	2.2%
	Total	**7**	**12.3%**	**3**	**3.8%**	**10**	**7.4%**
	Natural resources and environment						
	Agro-food	5	8.8%	9	11.7%	14	10.4%
	Forest	2	3.5%	1	1.3%	3	2.2%
	Sea economy	0	0.0%	1	1.3%	1	0.85%
	Water and environment	0	0.0%	0	0.0%	0	0.0%
	Total	**7**	**12.3%**	**11**	**14.3%**	**18**	**13.5%**
	Health, well-being and territory						
4.1%	Health	5	8.8%	12	15.5%	17	12.7%
	Tourism	2	3.5%	6	7.8%	8	6.0%
	Cultural and creative industries	1	1.7%	2	2.6%	3	2.2%
	Habitat	0	0.0%	1	1.3%	1	0.85%
	Total	**8**	**14.0%**	**21**	**27.2%**	**29**	**21.8%**
	Total	**57**	**100.0%**	**77**	**100.0%**	**134**	**100.0%**

Source: Own design based on data processed in SPSS.

5.2.6.4. Regional and sectorial convergence

When assessing the ***contribution of the projects on a regional level***, it was ascertained that 56.8% of the Demonstrator projects were integrated in *core* dimensions[48], particularly in the Centre (38.1%) and North (18.7%) of Portugal. It should be emphasized that the two typologies were relatively convergent, even though co-promotion projects were more involved with *core* domains (*Figure 41*).

Figure 41: Regional thematic domains according to project typology (2015-2019)

Domains per NUTS II region	Individual Demonstrator	Co-promotion Demonstrator	Total
NUTS II North			
Culture, creation and fashion	0	1	1
Mobility and environment industries	1	6	7
Agro-environmental systems and food	2	6	8
Advanced systems of production	2	13	15
Health and life sciences	0	2	2
Symbolic capital, technologies and tourism services	0	1	1
Sea resources and economy	0	0	0
Human capital and specialized services	6	4	10
NUTS II Centre			
Sustainable industrial solutions	12	19	31
Valuation of endogenous natural resources	3	12	15
Technologies for the quality of life	0	4	4
Territorial innovation	0	1	1
Energy efficiency	2	17	19
Territorial cohesion	0	1	1
Internationalization	16	19	35
NUTS II Lisbon			
Research, technology and health sciences	3	2	5
Knowledge, prospection and marine resources	0	0	0
Tourism and hospitality	0	0	0
Mobility and transport	2	1	3
Creative media and cultural industries	1	1	2
Advanced services for companies	4	3	7
Market services with strong knowledge intensity	7	5	11
NUTS II Alentejo			
Food and forest	2	1	3
Mineral, natural and environmental resources economics	2	0	2
Heritage, cultural and creative industries and tourism services	2	0	2
Critical technologies, energy and smart mobility	2	0	2
Social economy technologies and specialized services	1	1	2
NUTS II Algarve			
Tourism and sea	1	0	0
Agro-food, agro-processing, forest and green biotechnology	0	0	0
ICT and creative/cultural industries	0	0	0
Renewable energies	0	0	0

Source: Own design based on data processed in SPSS.

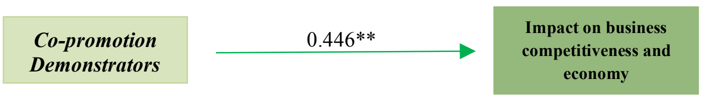
[48] *Core* dimensions are in **black**, rising dimensions in dark grey and wild-card dimensions in light grey. The domains, according to region, with the highest incidence in the Demonstrator projects are highlighted.

The sectorial domains that were more developed in this financial instrument were the advanced production systems combined with new information technologies, sustainable industrial solutions, internationalization, the valuation of endogenous resources, energy efficiency and market services with strong knowledge intensity (*Figure 42*).

5.2.6.5. Summary analysis of the *impact on business competitiveness and economy* dimension

In order to ascertain whether collaborative R&D, when compared to individual projects, leads to projects with a stronger impact on national and regional business strategy, by setting goals which are in accordance with Portugal 2020's *core* dimensions, a *one-way* ANOVA test was conducted. The *post-hoc*[49] tests brought to light statistical significance to accept and argue that, on average, the **performance** in the *impact on business competitiveness and economy* dimension **is different between the two typologies** ($F_{(1;72)} = 17.847$; *p-value* = 0.000). Co-promotion Demonstrators had a considerably higher *score* (4.3 against 3.8 average points).

Knowing that the closer the projects stand to the 5.0 bar, the larger the effect on business competitiveness and the access to external markets are, as well as the closer they stand to the priorities of Portugal 2020, it was easily discernible that co-promotion projects were the ones that better performed at the criteria in question (*Eta* = 0.446). However, regarding R&D post-project expense, individual projects stand out (2.0% against 1.0%)[50], which goes against the guiding hypothesis of this dimension of analysis.



** Dependency relationship is significant at the 0.01 level.

Source: Own design based on the data processed in SPSS.

5.2.7. Projects' merit: in summary

Factoring in two project typologies, one matching a more simplistic and less dynamic innovation process, carried out by one single company, and another which corresponds

[49] The *post-hoc* tests are conducted when the *one-way ANOVA* test for the equality of means (*Welch* or *Brown-Forsythe*) indicates that there is, at least, one group with a mean different from the others. In this case, the tests make it possible to pinpoint which peer groups differ from one another, on average terms.

[50] H_5 partially confirmed.

to a systemic and iterative process, led by constant (and retroactive) knowledge flows between companies and technological entities, it becomes imperative to ascertain whether there are statistically significant differences in their final performances, by measuring them through the *project merit* variable[51]. For this purpose, the *t test* was applied to two independent samples (Doane and Seward, 2008).

While conducting the test, three basic premises are considered – *independent samples, sampling of groups that are normally distributed* and the *homogeneity of variance* – which are featured in appendix[52].

Following this procedure, acknowledging the equality of variances, significant differences were apparent in the average performance of the Demonstrator projects ($t_{(72)} = 6.936$; *p-value* = 0.000). It was determined, with 95.0% of confidence, that the different averages between co-promotion and individual projects vary between 0.5 and 0.8 points. On average, co-promotion Demonstrators were more successful and satisfying.

Figure 42 sets forth the *TOP 10* of the most meritorious Demonstrator projects, comprised only of co-promotion projects, thereby supporting the previous conclusion.

Figure 42: *TOP 10* of the most meritorious Demonstrators in the applications (2015-2019)

Rank **by project merit**	**Type of organization**	**NUTS II**	**Technological field**	**Tech transfer intensity**	**Contribution to economy**	**Project merit *score***
Coopweld	Microenterprise	North	ICT and robotics	High	High	4.8
Gnesis	Microenterprise	Centre	Chemistry	High	High	4.5
Demo C parts	Small-scale enterprise	Centre	Mechanics and energy	Average	High	4.3
In2Dig	Medium-scale enterprise	Centre	ICT and robotics	High	High	4.1
CelSmartSense	Medium-scale enterprise	Lisbon	Chemistry	Average	Average	4.1
HS. Helios	Microenterprise	Centre	ICT and robotics	High	High	4.1
HS. Register	Microenterprise	North	ICT and robotics	High	High	4.1
PreSlabTec	Microenterprise	North	Mechanics and energy	High	High	4.1
Cork.a.tex-yarm	Medium-scale enterprise	Centre	Materials and construction	High	High	4.1
Peddir	Microenterprise	North	ICT and robotics	High	High	4.1

Source: Own design based on data processed in SPSS.

[51] $\overline{Project\ merit} = 0.3i + 0.2ii + 0.1iii + 0.1iv + 0.3v$. *(1)*

[52] *Vide* ***Appendix VII.VII.***

Furthermore, the variable that contributed the most for the final result was ascertained. This was attained through the execution of a test for the *Pearson's correlation coefficient (r),* also called bivariate correlation, which enables its measurement with statistical robustness (Webster, 2006). As expected, for a significance level of 95.0%, with the exception of the *degree of novelty of innovation activities* dimension ($r_{(42)} = 0.157$; *p-value* = 0.321), there is evidence regarding all the other dimensions to argue that they moderately influence the project merit (*p-value* = 0.000). *Figure 43* shows that the *intensity and adequacy of R&D inputs* dimension was the most determinant one, revealing a strong and direct relationship ($r_{(42)} = 0.757$; *p-value* = 0.000).

Figure 43: Pearson's correlation coefficient

	Project merit
Coherence and rationality	0.663**
Intensity and adequacy of R&D *inputs*	**0.757****
Degree of novelty of innovation activities	0.157*(ns)*
Scope of innovation *outputs* and diffusion	0.551**
Impact on business competitiveness and economy	0.568**

** Correlation is significant at the 0.01 level.
ns Correlation is not significant.

Source: Own design based on data processed in SPSS.

In order to assess whether the expected results were attained, the *Innovation Radar* questionnaire was conducted. It was executed in the field in collaboration with ANI, by the author of this thesis and an expert on each project's technological field, so as to ensure that the assessment is as robust as possible. The *ad-interim*/*ex-post* assessment was ruled by two analysis dimensions – *innovation potential* (IPI) and *innovator capacity* (ICI) – as well as by the identification of the more recurrent stages and obstacles in reaching the market.

Furthermore, this assessment sought to answer the starting question and **ascertain whether collaborative R&D and technology transfer led to innovation processes with more efficient and definite results in the market.**

5.3. *Ad-interim* and *ex-post* assessment

5.3.1. *Innovation Radar*'s key-facts

The intermediate and final assessment of the policy instrument under analysis within the scope of the current Community Framework (2014-2020) was thus conducted through IR. As was previously stated, this was a pioneering initiative, both in Portugal and on a European level, which involved the helpful assistance of the EC's researchers Daniel Nepelski and Vicent Van Roy, responsible for designing the tool. As the questionnaires were applied in the visits to the promoting companies, a database[53] was created with the performance of each project in the *45 variables* of the IR.

According to *figure 44*, between December 2018 and May 2019, **74 projects** were evaluated through the questionnaire, equipollent to an assessment rate of 100.0% of the current financial instrument.

As a result, 110 innovations were identified, which means that, on average, one Demonstrator project produced almost two innovations. The number of different promoters which sought to develop these innovations was 152, the equivalent to an average number of 2.1 innovators per innovation.

This conclusion is in accordance with what was addressed in topic 5.2.2, when the immaturity of the collaborative connections was determined, as most of them involve only 2 promoters.

Figure 44: *Key-facts* – innovations and innovators

Period of assessment	*19.12.2018 to 17.05.2019*
Number of projects assessed	74
Number of innovations	110
Number of distinct innovators	152
Average number of innovations *per* project	1.5
Average number of innovators *per* innovation	2.1

Source: Own design based on data processed in SPSS.

The following topic aims to analyze the first dimension of the IR – IPI -, which is comprised of three criteria, corresponding to the quality and preparation of the

[53] The database built in *IBM SPSS version 24* includes **3330 observations** for the execution of this analysis.

technologies, the management skills and the technologies' accessibility to the target markets.

5.3.2. Innovation potential[54]

This dimension aims to assess the effectiveness and readiness of the new technologies in the market and among potential users. *Figure 45* shows the descriptive statistics of the IPI and its criteria – *innovation readiness* (IRI), *innovation management* (IMI) and *market potential* (MPI)[55] – according to innovation potential category.

On average, the IPI *score* between all the innovations was 2.8 out of the sum total of 5.0 points, varying between 2.0 and 3.8 points for the *low potential innovations* and *high potential innovations categories*, respectively. The top-rated innovation reached a score of 4.7 points, whereas the lowest attained only 1.7 points.

Considering the criteria *per se*, it is observable that the IRI had the highest mean *score* (3.3) and the IMI the lowest (2.4). Based on this evidence, it is possible to conclude that, on average, innovation readiness and market potential were the strongest competencies of the Demonstrator projects financed between 2015 and 2019. Conversely, innovation management - related to risk management, absorptive capacity and knowledge management – is the weakest criterion of this policy instrument.

Figure 45: Descriptive statistics of the indicators for the assessment of innovation potential

		No. of innovations	Mean	Std. Deviation	Min.	Max.
Assessment criteria	Innovation readiness	110	3.3	0.9	0.5	4.9
	Innovation management	110	2.4	0.8	0.8	4.8
	Market potential	110	2.7	0.6	1.7	4.2
	Innovation potential	**110**	**2.8**	**0.6**	**1.7**	**4.7**
Innovation potential indicator	Low potential innovations[56]	25 (23.8%)	2.0	0.1	1.7	2.2
	Medium potential innovations[57]	59 (56.2%)	2.8	0.3	2.5	3.4
	High potential innovations[58]	21 (20.0%)	3.8	0.1	3.5	4.7

Source: Own design based on data processed in SPSS.

[54] *Innovation potential* is a composite quantitative variable that encompasses scores between 1 (*mediocre*) and 5 (*exceptional*), resulting from the aggregation of the three criteria comprising it.
[55] Cronbach's α = 0.708, which means that there is internal consistency between the three criteria of the current dimension.
[56] Low potential innovations: $IPI_{Low} < 2.2$. *(4)*
[57] Medium potential innovations: $2.2 \leq IPI_{Medium} < 3.4$. *(5)*
[58] High potential innovations: $IPI_{High} \geq 3.4$. *(6)*

5.3.2.1. Innovation readiness

A successful launch of innovative products or services begins with the identification of technologies which are ready to be commercialized (Cooper, 2007). In this regard, the ***IRI*** criterion sought to identify the various stages that comprise the process of technological development before entering the market. In other words, it aimed at defining the stage of the innovation's progress.

In this respect, it was determined that the vast majority of the Demonstrator projects are "*being exploited*" (54.0%), estimating the release of the innovation in the market "*in between 1 to 3 years*" (43.2%).

When comparing the two typologies, it was ascertained that, for a significance level of 5.0%, there is statistical evidence to argue that co-promotion projects stood out, both in the *development phase* ($x^2_{(2)} = 6.304$; *p-value* = 0.032) and regarding the *time to market* criterion ($x^2_{(3)} = 11.192$; *p-value* = 0.010).

Its distinctiveness was also confirmed when the innovations were distributed according to IRI and innovation potential category. Even though around 62.2% of the Demonstrators correspond to the *medium potential innovation* category, the mean *scores* for market readiness ranged, according to typology, between 1.0 and 1.2 points, which denotes a considerable difference, given the breadth of the scale (1-5 points) (*Figure 46*).

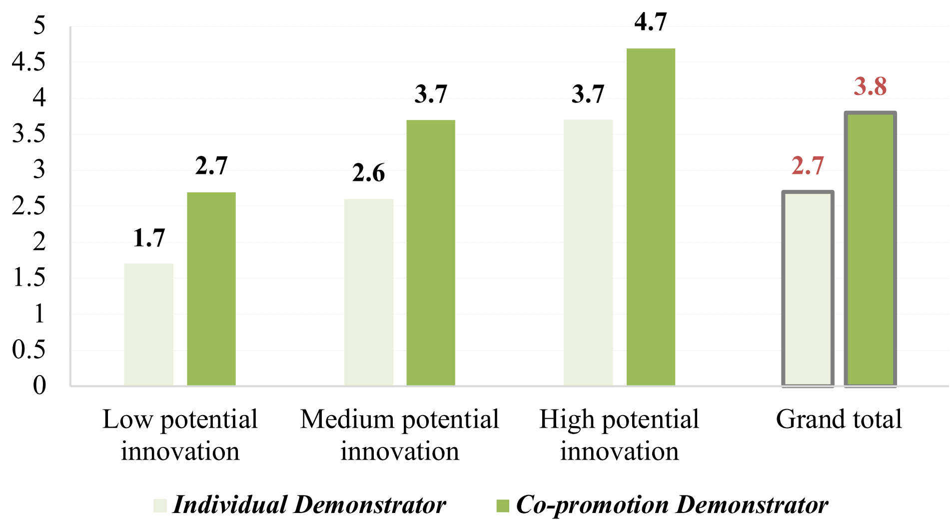
Figure 46: Technological progress of the Demonstrators, according to project typology (2015-2019)

Criteria	*Individual Demonstrator*		*Co-promotion Demonstrator*		Total	
	N	% Total	N	% Total	N	% Total
Development phase						
Under development	2	6.2%	1	2.4%	3	4.1%
Developed but not exploited	18	56.3%	13	30.9%	31	41.9%
Being exploited	12	37.5%	28	66.7%	40	**54.0%**
Time to market						
Less than 1 year	3	9.4%	10	23.8%	13	17.6%
Between 1 and 3	11	34.4%	21	50.0%	32	**43.2%**
Between 4 and 5	10	31.2%	10	23.8%	20	27.0%
Between 6 and 10	8	25.0%	1	2.4%	9	12.2%
More than 10	0	0.0%	0	0.0%	0	0.0%

Source: Own design based on data processed in SPSS.

This means that individual projects carried out mainly the stages of conceptualization and development of prototypes and fell short on viability studies, complying with existing standards and contributing to standards (*Figure 47*).

Figure 47: IRI median scores, according to category of innovation potential and to project (2015-2019)



Source: Own design based on data processed in SPSS.

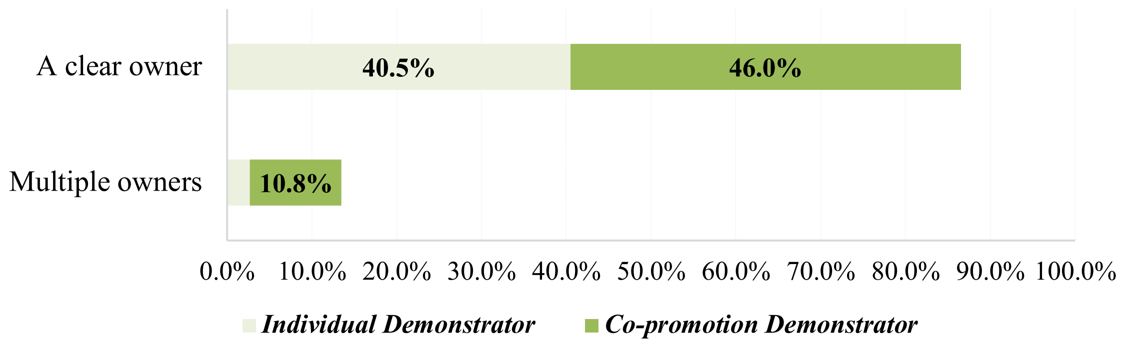
Having tested that hypothesis that collaborative R&D leads to technologies with more advanced levels of *innovation readiness* and which stand closer to the market, the *one-way ANOVA* test was applied. It was ascertained that statistical evidence exists to argue that co-promotion projects are better prepared regarding technological resources, for instance in the pilot-testing stages and in demonstration activities for potential customers/users[59].

5.3.2.2. Innovation management

When addressing the issue of the project consortium and its commitment to bring innovation to the market, a differentiation was made between innovations with a single owner and innovations with multiple owners. 86.5% of all Demonstrators had a *"a clear owner"*, whereas the property rights of the remaining innovations belonged to "*multiple owners"* (13.5%). This preponderance was observed in the two typologies ($x^2_{(1)} = 2.545$; *p-value* = 0.103) (*Figure 48*).

[59] H_A confirmed.

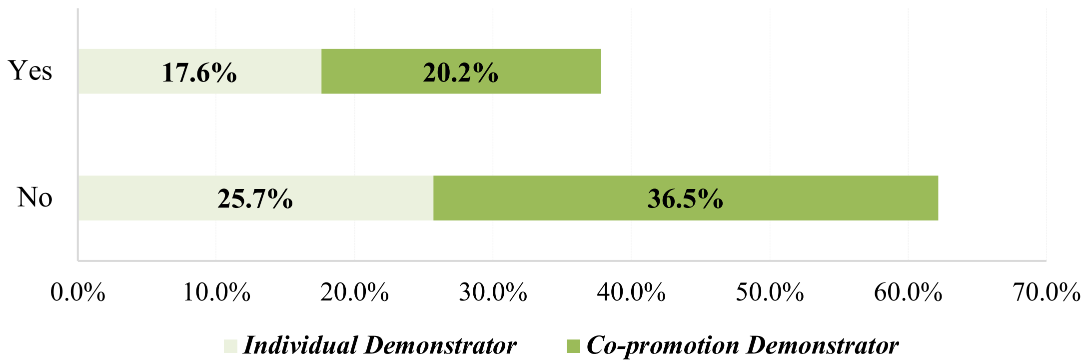
Figure 48: Ownership of innovation according to project typology (2015-2019)



Source: Own design based on data processed in SPSS.

When evaluating the projects in regard to problems of intellectual property inside the consortia, which might compromise the capacity of the organization(s) to exploit new technologies, it was determined that 62.2% of the Demonstrators did not exhibit any IPR obstacle. *Figure 49* shows that, regardless of project typology, the distribution of the Demonstrators on this matter is relatively equitable (Cramer's V $_{(74)}$ = 0.050; *p-value* = 0.809).

Figure 49: IPR issues within the consortium (2015-2019)



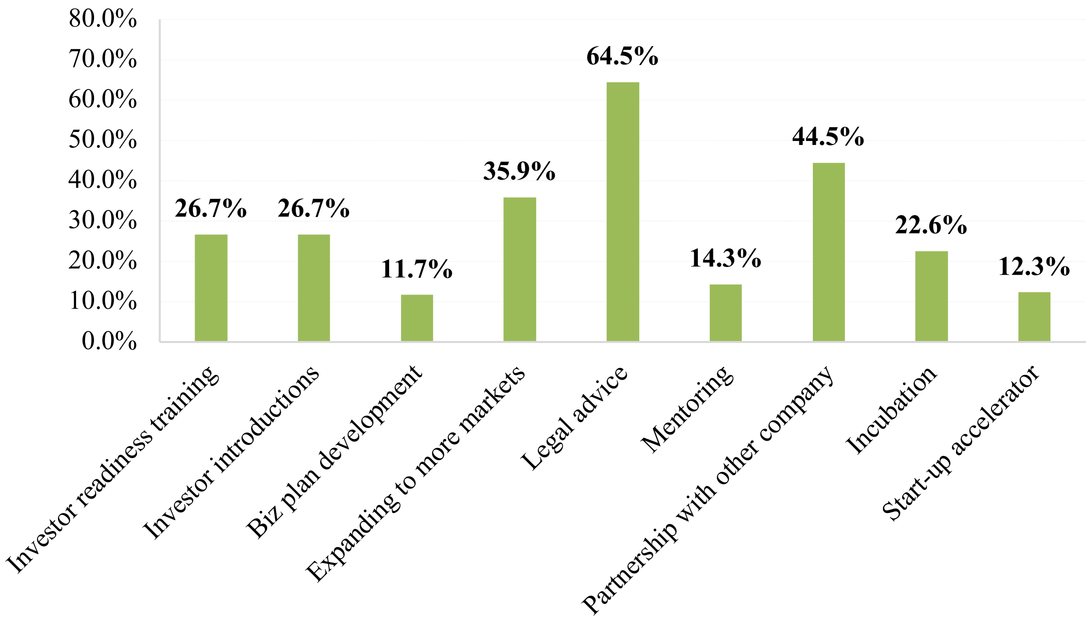
Source: Own design based on data processed in SPSS.

In order to better understand the management needs of the Demonstrators' consortia, IR inquired about their main weaknesses. *Figure 50* shows that the most common requirements are *"legal advice"* (64.5%), *"partnerships with other companies"* (44.5%) and the *"expansion to further markets"* (35.9%), in other words, particularly external factors which might facilitate their access to the target-market and the increase of their competitiveness. The less frequent needs, in turn, are connected to internal factors, such as the creation of "*business plans*" (11.7%), *"participation in a start-up accelerator"* (12.3%) and *"mentoring"* (14.3%).

From this analysis, it was possible to conclude that the main frailty derives from low patents' registration, as the IPR register is considered to be "*quite expensive and cumbersome*", both in Portugal and in the EU (De Coster and Butler, 2005; Doh and Kim, 2014).

Moreover, it stands to mention that the observed requirements are related to the lack of connection, interaction and coordination between the elements of the innovation system (Carayol, 2003) and to the poor use of the innovative potential for the increase, in number and scope, of high-intensity technology partnerships (Chesbrough and Bogers, 2014), which would be paramount for the elimination of any of the above mention necessities.

Figure 50: The Demonstrators' main needs in innovation management (2015-2019)

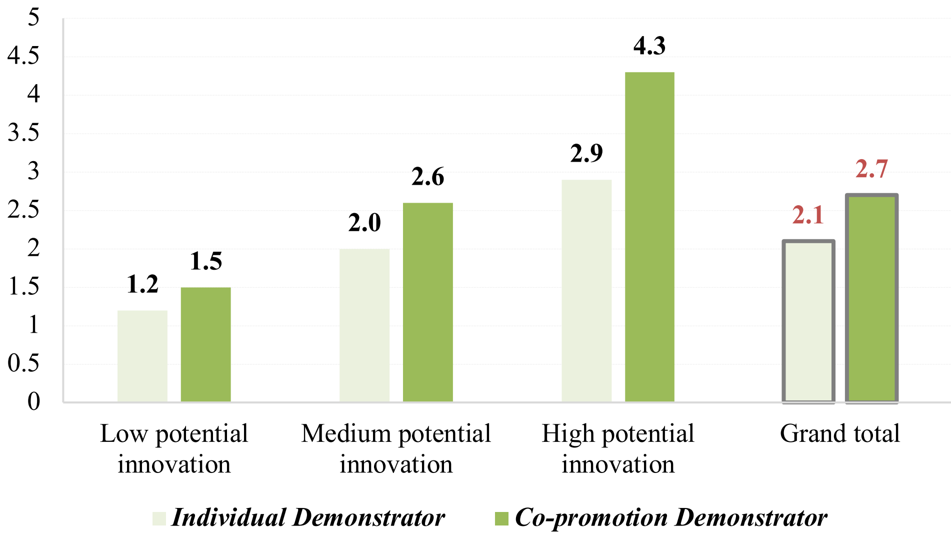


Source: Own design based on data processed in SPSS.

So as to test the hypothesis that collaborative R&D leads to projects with more skills and competencies on the level *of innovation management*, the *t test* was conducted for the two typologies. Assuming the heterogeneity of variance of the IMI criterion, it was ascertained that the means of 2.7 points out of 5.0 (*Std. deviation*= 0.9) for co-promotion projects, and of 2.1 points (*Std. deviation* = 0.5) for individual Demonstrators are, indeed, different. This demonstrates that the occurrence of technology transfer influences, in a moderate and direct way, performance on the innovation management domain ($t_{(68.608)} = 3.935$; p-value=0.000; *Eta* = 0.399) (*Figure 51*)[60].

Despite the fact that both typologies were, on average, assessed in a not very resolute way, 84.0%-88.1% of the Demonstrators exhibited *medium* or *high potential of innovation* in this criterion, with the high mean score of co-promotion projects belonging to the *high potential innovation* category standing out (4.3 points).

Figure 51: Median values of the IMI according to category of innovation potential and to project typology (2015-2019)



Source: Own design based on data processed in SPSS.

5.3.2.3. Market potential

The ***MPI*** criterion aggregated questions concerning simultaneously the market and technology, since both of these factors determine the economic benefits of a commercially viable innovation (Goldenberg *et al.*, 2001).

As was previously established, the MPI depends on the prospective conditions of the market for a given process, product or service. Therefore, its evolution/adaptation must be carried out vigorously, including the determination of its innovation level, when confronted with the technologies already existing in the market (Kapil, 2013).

It was thus possible to ascertain that 35.1% of the solutions were *"innovative, but difficult to convert the customers"*, particularly when developed by individual projects

[60] H_B confirmed.

(37.5%). This deduction is connected to the dependency relationship between the type of Demonstrator and the *level of innovation* ($x^2_{(3)} = 11.135$; *p-value* = 0.010)[61].

As can be observed in *figure 52*, the vast majority of co-promotion Demonstrators proved to be "*very innovative*" (23.9%), *"with clearly innovative advantages which can be easily appreciated by the customers"* (33.3%), in contrast to what was verified in individual projects. It should be emphasized, however, that this observation is partly connected to the fact that more than 60.0% of the individual projects reported, in the applications, to be developing "*incremental innovations*".

Figure 52: Level of innovation, according to project typology (2015-2019)

Criteria	***Individual Demonstrator***		***Co-promotion Demonstrator***		**Total**	
	N	**% Total**	**N**	**% Total**	**N**	**% Total**
Level of innovation						
Some distinct, probably minor improvements over existing products	10	31.3%	4	9.5%	14	18.9%
Innovative but could be difficult to convert customers	12	37.5%	14	33.3%	26	35.1%
Obviously innovative and easily appreciated advantages to costumers	9	28.1%	14	**33.3%**	23	31.1%
Very innovative	1	3.1%	10	**23.9%**	11	14.9%

Source: Own design based on data processed in SPSS.

It should be emphasized that being clearly forces the organizations not to be focused merely on technology production and commercialization, but also on acknowledging and meeting their own internal needs in order to increase their efficiency and competitiveness (Cooper, 2007; Kirchberger and Pohl, 2016). In this regard, the IR distinguishes between *"commercial exploitation"* and *"internal exploitation"*.

Figure 53 shows that commercial exploitation is planned for in 52.7% of the Demonstrators, whereas 45.9% plan to be exploited internally, by means of changes in the organization and/or implementation of new internal processes.

[61] The independence test *Chi-square* was applied.

It was interesting to observe that the type of exploitation varied considerably in accordance with the typology (Cramer's V = 0.457; *p-value* = 0.000), since the large majority of co-promotion Demonstrators aims for *"commercial exploitation"* (71.4%), whilst the individual ones mostly seek *"the implementation of their technologies in a partner"* (71.9%).

Figure 53: Exploitation of the innovation according to project typology (2015-2019)

Criteria	*Individual Demonstrator*		*Co-promotion Demonstrator*		Total	
	N	% Total	N	% Total	N	% Total
Innovation exploitation						
No exploitation	0	0.0%	1	2.4%	1	1.4%
Internal exploitation	23	**71.9%**	11	26.2%	34	45.9%
Commercial exploitation	9	28.1%	30	**71.4%**	39	**52.7%**

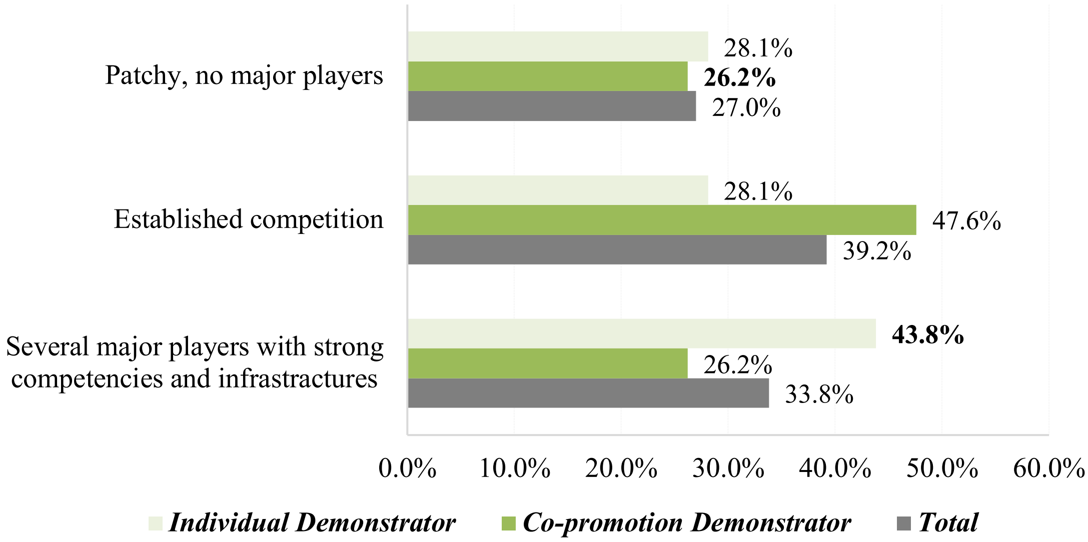
Source: Own design based on data processed in SPSS.

In addition to the identification of internal business strategies, technology commercialization relies on other market-related features in order to be successful, such as structure and maturity (Blind, 2016; Evanschitzky *et al.*, 2012). These features include the existence of definable markets, the absence of strong competitors and the size and growth rate of the target-markets (Blind, 2011, 2016).

Regarding *market structure,* it is possible to observe in *figure 54* that 39.2% of all Demonstrators are integrated in markets "*with established competition, but with no technologies similar to the ones being offered*", whereas 27.0% "*does not have main competitors",* leaving space for the introduction of these technologies and their commercialization.

When assessing *competitiveness in the target-market* according to project typology, no statistical evidence was found to prove dependency ($x^2_{(2)} = 3.444$; *p-value* = 0.185). The type of Demonstrator, therefore, does not seem to influence significantly the structure of the target-market of these new technologies. Yet, it was possible to ascertain that individual Demonstrators aim more substantially at *"markets with multiple competitors and strong established skills and infrastructures"* (43.8%), whereas co-promotion projects present technological solutions which are much more distinguishable (26.2%).

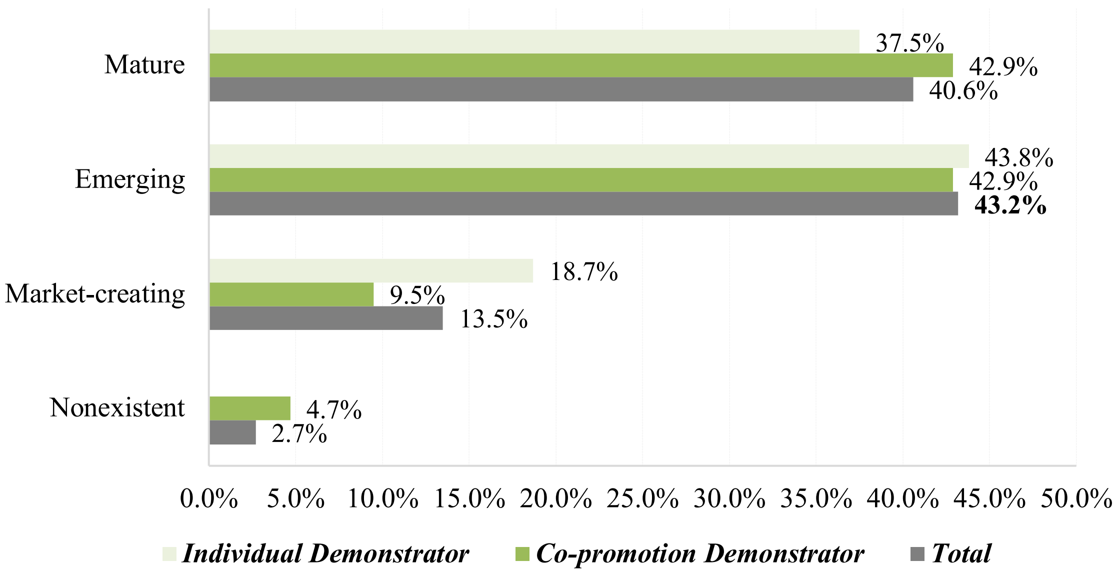
Figure 54: Market structure, according to project typology (2015-2019)



Source: Own design based on data processed in SPSS.

In accordance with the foregoing, it was observed that 77.0% of the developed technologies have other relevant markets on which the innovators are not yet focusing, since 69.5% of the target-markets are "*growing*", particularly in the fields of the ICT (55.4%) and mechanic engineering (13.5%). This statement is further corroborated by the *market maturity* indicator, through which it was ascertained that 43.2% of the funded innovations are integrated in "*emerging markets*" (*Figure 55*).

Figure 55: Market maturity, according to project typology (2015-2019)



Source: Own design based on data processed in SPSS.

The *one-way ANOVA test* was conducted in order to compare the *market potential* mean in the two types of Demonstrators. Having ascertained the equality of the variances (Levene $_{(1;72)}$ = 0.255; *p-value* = 0.615), it was concluded that, on average, co-promotion projects generate more value added for the relevant markets, by means of more innovative, differentiated and competitive technologies ($F_{(1;72)}$ = 14.307; *p-value* = 0.000)[62].

Below, the second IR dimension is analyzed – the ICI -, being comprised of two criteria and based upon the premise that the companies' innovative performance can be captured through their inherent capacities to innovate (Assink, 2006), as well as through the conditions in which they operate (Pandza *et al.*, 2011).

5.3.3. Innovator capacity[63]

It is possible to attain a general overview of the innovators' performance by means of two criteria – which arithmetically constitute the ICI[64].

On average, the ICI *score* for all the 152 innovators is of 2.5 out of a sum total of 5.0 points, varying between 1.2 and 3.7 for *low* and *high capacity* innovators, respectively. The highest-rated innovator achieved a *score* of 4.6 points, whereas the lowest-rated one attained only 0.9 points. Considering the two criteria individually, it was possible to observe that the IEI exhibits the highest mean *score* (2.7) and the IAI the lowest (2.2), even though the IEI scores are more unstable than the IAI ones (*Std. deviation* = 1.1; *Std. deviation* = 0.8) (*Figure 56*).

Figure 56: Descriptive statistics of the indicators for the assessment of the innovator capacity, according to category of innovation

		No. of innovators	Mean	Std. Deviation	Min.	Max.
Assessment criteria	Innovator's ability	152	2.2	0.8	1.0	4.2
	Innovator's environment	152	2.7	1.1	0.5	5.0
	Innovator capacity	**152**	**2.5**	**0.9**	**0.9**	**4.6**
Innovator capacity indicator	Low capacity innovators[65]	13 (17.6%)	1.2	0.2	0.9	1.5
	Medium capacity innovators[66]	50 (65.6%)	2.5	0.4	1.6	3.3
	High capacity innovators[67]	11 (14.9%)	3.7	0.1	3.7	4.6

Source: Own design based on data processed in PSS.

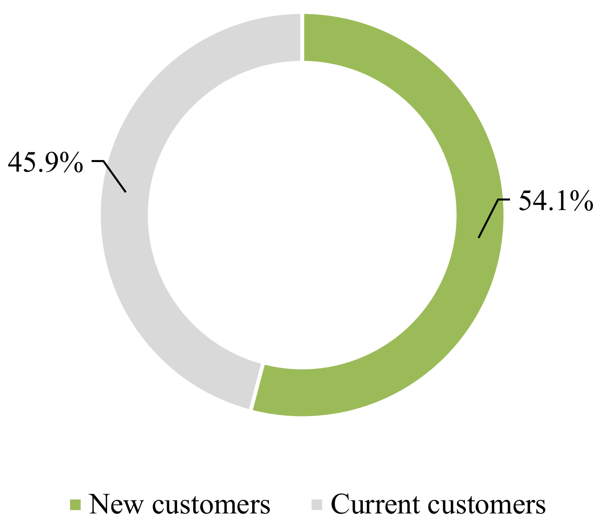
[62] H_C confirmed.
[63] *Innovator capacity* is a composite quantitative variable that encompasses scores between 1 (*mediocre*) and 5 (*exceptional*), resulting from the aggregation of its two constituting criteria.
[64] Cronbach's α = 0.797, which means that there is internal consistency between the two criteria of the current dimension.
[65] Low capacity innovators: $ICI_{Low} < 1.6$. *(7)*
[66] Medium capacity innovators: $1.6 \leq ICI_{Medium} < 3.4$. *(8)*
[67] High capacity innovators: $ICI_{High} \geq 3.4$. *(9)*

In addition to the above-mentioned, it is possible to argue that the quality of the innovators' ability and environment is not the same in all projects, as is ascertained below.

5.3.3.1. Innovator's ability

Regarding the ability to innovate, it was established that, on average, the innovators developed technologies which are predominantly used by *"new customers"* (54.1%). However, significant differences were recognizable when comparing the two typologies, since most individual projects aim for the same target-audience (68.8%), in stark contrast to projects derived from collaborative methods (Cramer's V = 0.400; *p-value* = 0.010) (*Figure 57*).

Figure 57: Demonstrator projects' target customers (2015-2019)



Source: Own design based on data processed in SPSS.

Some empirical studies suggest that innovation capacities, concerning both technology and business, have a considerably higher impact on the company's performance than R&D-oriented measures (Assink, 2006; Forsman, 2011; Teece, 2011).

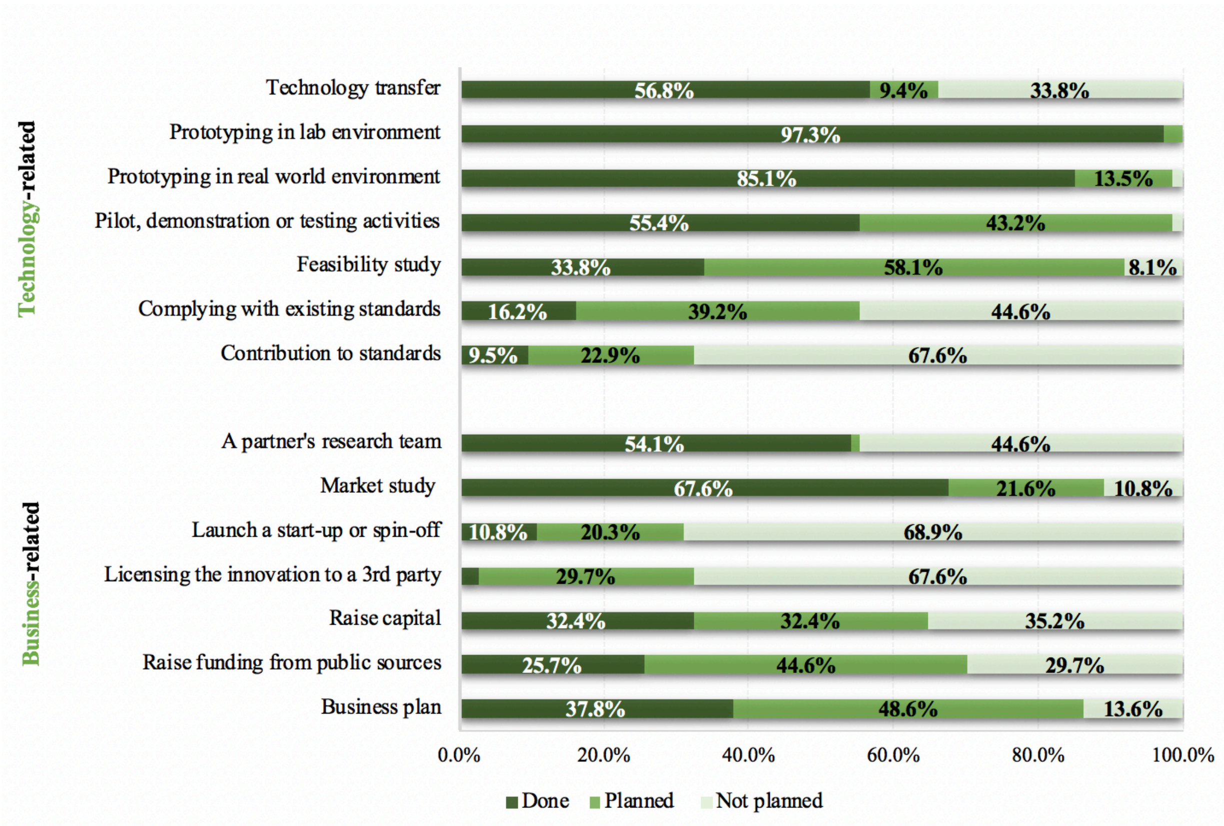
In this regard, it was determined that most inventors have "*between 1 to 4 necessities*" when bringing the invention to the market (58.1%).

On average, projects focus more on stages connected to the technologies than to the ones concerning business. Interestingly, 91.9% of the projects striving to sell their innovations *"has conducted or plans to conduct a viability study"*. Conversely, only 31.1% *"has launched or intends to launch son a start-up or spin-off"*.

Additionally, it stands to mention that only 37.8% of the innovators have designed *"a business plan"*.

Activities involving the participation of interaction with actors outside the projects are relatively rare, since only 25.7% of the projects sought *"public funding or other type of external help"*. In this regard, it was concluded that the three less frequent stages among the Demonstrators are the "*launching a start-up or a spin-off"* (68.9%), *"licensing the innovation to a third party"* (67.6%) and *"establishing a partnership with other company"* (44.6%) (*Figure 58*).

Figure 58: Advances of the Demonstrators' innovators in bringing technology into the market



Source: Own design based on data processed in SPSS.

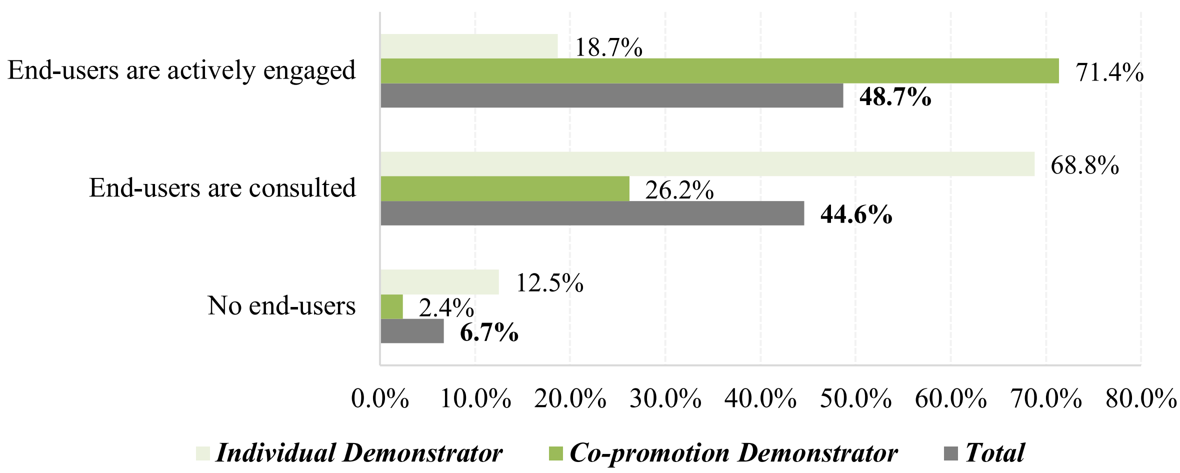
5.3.3.2. Innovator's environment

Regarding the *innovator's environment*, the aim was to understand the level of interaction with partner organizations and their commitment to exploiting the project results, also considering the organizations that are directly interested in applying those innovations (Van Roy and Nepelski, 2018).

It was determined that collaborative R&D mobilizes "*the active presence of end-users in its projects*" (71.4%), whilst individual projects have fewer substantial channels, *"consulting potential end-users"* (68.8%) or *"not establishing any contact"* (12.5%).

Figure 59 shows that working together with other organizations grants the innovators access to other forms of knowledge and complementary assets (Pandza *et al.*, 2011), functioning as *radars* for *"new end-users"* (Hull and Covin, 2010). This means that collaborative R&D fosters the creation and mobilization of more partnerships and customers than individual efforts could ever allow for.

Figure 59: Engagement of end-users with the innovators

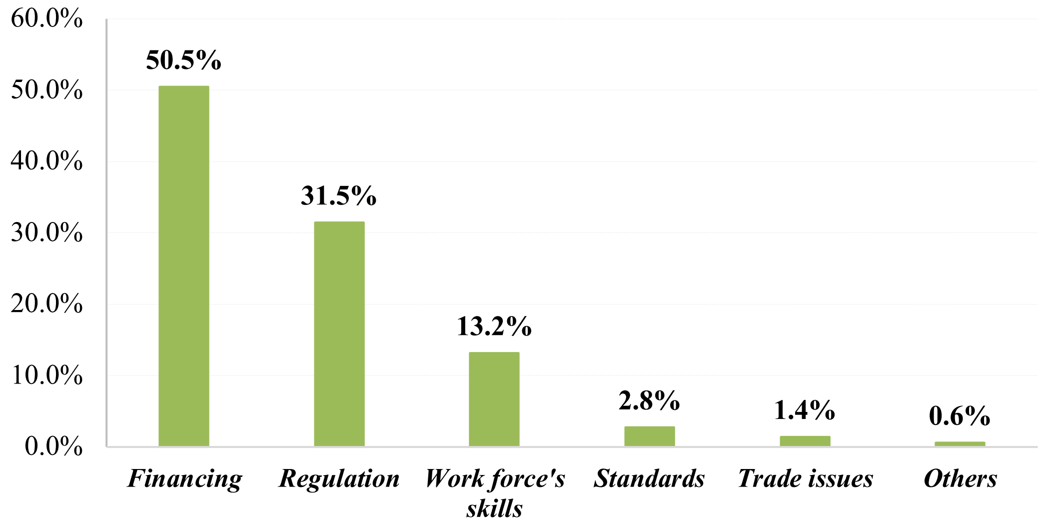


Source: Own design based on data processed in SPSS.

52.7% of the relevant partners exhibited a *moderate* level of commitment to exploiting the innovation. Statistical evidence was found to argue that in collaborative R&D this commitment is more significant ($x^2_{(2)} = 3.444$; *p-value* = 0.185), since 10 co-promotion projects proved to be quite committed (*i.e., with a very high level of commitment*), which was not the case with any of the individual projects.

It stands to mention that the results were not promising due to the existence of external bottlenecks which compromised the partners' capacity to exploit those solutions. For the great majority of Demonstrator projects (50.5%), *"lack of funding"* is taken as the main obstacle hindering the exploitation of the innovation. *"Regulation"* (31.5%) and *"work force's skills"* (13.2%) are also relatively significant. Among the less damaging bottlenecks, there are "*standardization"* (2.8%) and *"trade issues between the member states"* (1.4%) (*Figure 60*).

Figure 60: External bottlenecks that compromise the capacity of exploiting the innovations



Source: Own design based on data processed in SPSS.

Having established a comparison between the steps that organizations have taken or plan to take in order to bring innovations (closer) to the market and the external obstacles standing in their way (*Figure 63*), it is possible to identify a contradiction between what are claimed to be the constraints on funding and the actual conduct of the project organizations. Whereas 50.5% of the innovators consider lack of funding to be the main obstacle hindering the exploitation of the innovation, only 25.7%-32.4% of the promoters actually sought public or private financing.

When comparing the two typologies, it was determined that, indeed, co-promotion projects are more qualified, through innovators that boost radical solutions and make great technological and commercial efforts, to lead them more effectively to the target-market ($t_{(59.376)} = 6.030$; *p-value* = 0.000). They are also the ones displaying more proactive and committed attitudes in exploiting technologies ($t_{(72)} = 3.548$; *p-value* = 0.001)[68].

This conclusion is corroborated by *figure 61*, which shows that the 10 Demonstrators with the best performance in this dimension result from a process of **collaborative innovation**.

[68] H_D and H_E confirmed.

Figure 61: Top 10 of the innovators with bigger capacity to innovate (2015-2019)

Rank **by ICI**	**Co-promoters**	**Type of leading innovative company**	**NUTS II**	**City**	**IAI *score***	**IEI *score***	**ICI *score***
Gnesis	***Grapherest, S.A.*** *Display, S.A.* *University of Minho* *University of Aveiro.*	Microenterprise	Centre	Aveiro	4.1 (High)	5.0 (High)	**4.6** **(High)**
PreSlabTec	***Civitest – Pesquisa de Novos materiais para Engenharia Civil, Lda.*** *Serralharia Cunha, Lda.*	Microenterprise	North	Braga	4.0 (High)	5.0 (High)	**4.5** **(High)**
Coopweld	***SARKKIS-ROBOTICS, Lda.*** *INESC TEC – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência.* *ISQ – Instituto de Soldadura e Qualidade.* *Norfersteel – Construções e metalomecânica, S.A.*	Microenterprise	North	Oporto	4.1 (High)	4.5 (High)	**4.3** **(High)**
Cork.a.tex-yarm	***Têxteis Penedo, S.A.*** *SEDACOR - Sociedade Exportadora de Artigos de Cortiça, Lda.* *CITIVE – Centro Tecnológico das Indústrias Têxtil e do Vestuário de Portugal.*	Medium-scale enterprise	Centre	Aveiro	3.3 (Medium)	5.0 (High)	**4.2** **(High)**
In2dig	***INTERMOLDE – Moldes Vidreiros Internacionais, Lda.*** *INOV – Instituto de Novas Tecnologias.* *CENTIMFE – Centro Tecnológico da Indústria de Moldes, Ferramentas especiais e Plásticos.*	Medium-scale enterprise	Centre	Leiria	4.0 (High)	4.0 (High)	**4.0** **(High)**

DEMO@Polyfenton	***Ventiláqua, S.A.*** *University of Coimbra.*	Small-scale enterprise	Centre	Coimbra	4.0 (High)	4.0 (Medium)	**4.0 (High)**
Bepim III	***Tecnifreza – Indústria de Moldes, S.A.*** *3D-TECH – Produção, otimização e reengenharia, Lda.*	Medium-scale enterprise	Centre	Marinha Grande	3.2 (Medium)	4.5 (High)	**3.9 (High)**
Demo C parts	***Plácido Roque – Indústria de Moldes e Máquinas, Lda.*** *Moldetipo II – Engineering Moulds and Prototypes, Lda.* *Polytechnic Institute of Leiria.*	Small-scale enterprise	Centre	Marinha Grande	4.2 (High)	3.5 (Medium)	**3.9 (High)**
HS. Register	***HLTSYS-HEALTH SYSTEMS, Lda.*** *Unidade Local de Saúde de Matosinhos, EPE.* *University of Oporto.*	Microenterprise	North	Oporto	4.0 (High)	3.5 (Medium)	**3.8 (High)**
Saltquanti	***Evoleo Technologies, Lda.*** *University of Oporto.*	Small-scale enterprise	North	Maia	3.0 (Medium)	4.5 (High)	**3.8 (High)**

Source: Own design based on data processed in SPSS.

Note: The Demonstrator projects are arranged according to increasing order of the *innovator capacity* (ICI) *ratings*.

5.3.4. Degree of success: in summary

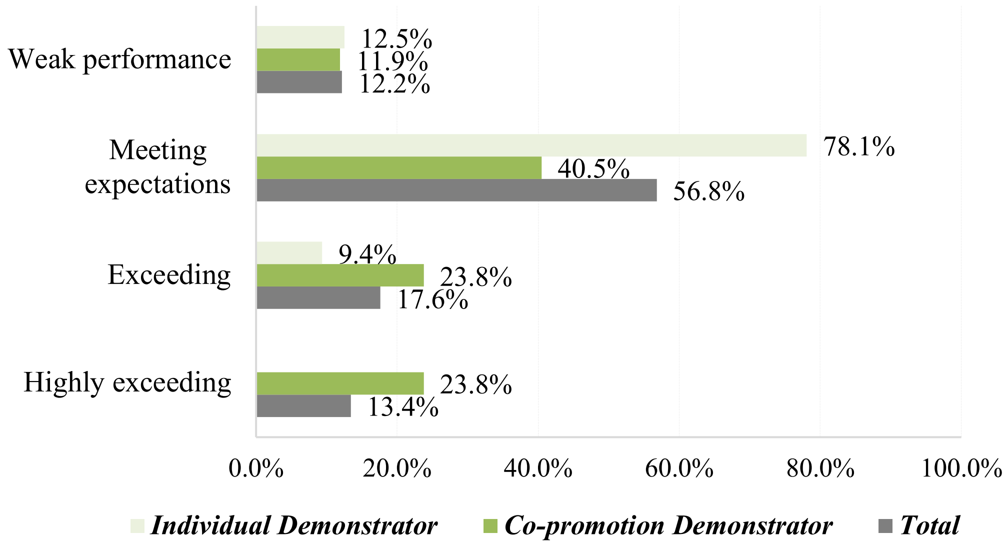
Know-how is a requirement for the development of a knowledge-based economy, but it is not enough. Knowledge needs to be developed and explored. For this reason, there is an urgent need to assess the new technologies and their innovators (Carayol, 2003; Bercovitz and Feldman, 2006). Fostering this movement and creating the conditions for collaborative R&D to generate actual economic results is imperative for Portugal, which remains a moderately innovative country, with scant collaboration *networks* between the companies and national technology infrastructures (Arora and Gambardella, 2001; Assink, 2006). Throughout this analysis, it was observed that knowledge only becomes economically valuable through its experimentation, validation and application by the business sector. Furthermore, even though relatively positive results were attained, the stages concerning business fell short of expectations, mainly due to the performance registered in the *innovation management* dimension.

This occurrence led to the conclusion that, in the case of this policy instrument, the steps concerning technology *per se* are regarded as more important in order for the innovation to reach the market. The tranquility of the innovators when searching for new partners and/or launching a *start-up* or *spin-off* was observed just as often. The emphasis was, therefore, placed fundamentally on what can be improved internally, regarding the current or a future project, with the same partners. No interest in establishing partnerships or *networks* with external actors specialized in technological fields (*e.g.* management mentors or venture capitalists) was thus identified, particularly in individual projects.

When assessing the Demonstrators' *degree of success*, projects deriving from collaborative R&D stood out significantly ($t_{(70.585)} = 6.591$; *p-value* = 0.000), in terms of both *innovation potential* and the promoters' *innovation skills*. On average, this typology reached a final *score* of 3.1 points (*Std. deviation* = 0.7), whereas individual Demonstrators achieved only 2.2 points (*Std. deviation* = 0.4), a rating lower than the midpoint of the scale of analysis (1-5).

This conclusion resulted in a considerably differentiated assessment of the projects' performance. As can be seen in *figure 62*, 31.0% of the Demonstrators proved to be quite satisfying (*i.e., "exceeding"* or *"highly exceeding expectations"*), among which 27.0% are co-promotion projects. Individual projects, in turn, were considered, on average, to have "*met the expectations and the goals set in the application"*, in spite of some slight deviations (78.1%).

Figure 62: The Demonstrators' performance, according to project typology (2015-2019)



Source: Own design based on data processed in SPSS.

It should be noted that in the *innovation potential* dimension, *innovation management* was the criterion in which the two typologies differed the most, with co-promotion projects standing out positively. On the other hand, in the *innovator's capacity* dimension, it was the *innovator's ability* criterion which exhibited the greatest differential. This means that for the increase of the innovations' success in individual projects, measures concerning technology and the business model itself must be taken, as well as the clarification of the innovation property, the establishment of external partnerships, mentoring and the guarantee of public and/or private funding.

It is therefore crucial to redesign the incentive systems of advanced knowledge collaborative production, so that "virtuous unions can occur and bear fruit within those [more fragile] fields", since "what has been done is interesting, but not enough and, worse still, at times not very impactful"[69].

In short, by inquiring the expert of each Demonstrator on whether he/she would invest in the developed innovation(s), it was possible to determine that 83.8% of the projects were considered *"viable and promising for the market"*, among which 58.1% stem from a collaborative process.

This deduction corroborates the conclusions that were reached in the theoretical and empirical studies reviewed and addressed throughout this research.

[69] *Vide* https://jornaleconomico.sapo.pt/noticias/manuel-mira-godinho-mudar-a-inercia-e-abrir-as-mentes-para-novas-atitudes-405637 (Accessed on the 26th May 2019).

CHAPTER 6
FINAL REMARKS, POLITICAL IMPLICATIONS AND FUTURE RESEARCH PERSPECTIVES

The current chapter sets forth the most pertinent contributions of this Master's research work, which now reaches its conclusion. As such, I will begin by summarizing the argument provided and by putting forward the main answers to the question under analysis, from the perspectives of both the *ex-ante* and *ex-post* assessments, underlining their implications for public economy and policy. Thereafter I will highlight the main limitations and conclude by offering suggestions for future research.

6.1. Final remarks and political implications

This research was primarily aimed at assessing the effects of collaborative R&D and technology transfer on the development of innovations, by means of multiple criteria, both at an initial stage of the process and at the time of its conclusion and pre-commercialization. *Co-promotion Demonstrator* projects were taken as *proxy* to the phenomena under analysis. A holistic methodology was applied to them which encompassed different, albeit complementary, research methods and techniques. Therefore, by conducting a document analysis of their application proposals, a *score* was assigned to each innovative project (on a scale of 1-5) so as to assess their efficiency. This was followed by a prominently quantitative analysis, by means of the IR questionnaire, which sought, in turn, to analyze their effectiveness in the market.

Being a competitive economy entails being an innovative economy with the capacity to utilize the results of technological and scientific research in order to build new equipment, provide new services, develop new production means, create new solutions for existing problems, and train new highly-qualified generations, who know how to transform new knowledge so as to sustain the chain of progress (EC, 2017; EU, 2013, 2014, 2016).

For this purpose, considering the theoretical and empirical review that was conducted, it is perfectly clear that, however relevant technological innovation may be, it has no impact on the economy unless companies take action for its economic valuation (Kovács, 2000). Nevertheless, its importance and central position is different today from what it was in previous decades.

At the beginning of the 20th century, the company was the *core* of the entire innovation process and, as such, the entrepreneur was the agent behind 'creative destruction' (Schumpeter, 1950, 1982). The process was described through linear models which considered that R&D was a primary and critical factor, with a direct relationship being established between R&D expenses in the business world and the achievement of technological innovation.

Decades later, scholarly debates concerning innovation brought to light the integrated perspective of the process, forcing political models to evolve into non-linear descriptions and applications (Lundvall, 1992). Besides this progress, innovation is currently a dynamic and additive learning process, which crosses R&D formal borders, with companies establishing relationships with a wide range of partners (*e.g.* companies, universities, R&D centers, clients, suppliers, among others) (Bercovitz and Feldman, 2006). In this regard, technology transfer is crucial nowadays, since it enables the absorption of knowledge into the business world and operates on the basis of a cooperation and coordination commitment with the remaining economic agents, for the optimization of the existing capacities (Hu *et al.*, 2006; Zuniga and Correa, 2013; Scandura, 2016).

Even though the linear approach is still visible in several measures being put into practice, both in the EU and Portugal (Santos, 2016), there are currently incentive systems which enable technology infrastructures to effectively and adequately meet the requirements of companies and the economy in general (Call no. 57-A/2015). However, the existence of these priorities has not necessarily brought about an integrated, system-oriented assessment (Chesbrough and Bogers, 2014). It is clear that a holistic assessment is lacking, one that demands not only ethics from the assessor, who is expected to be scientifically engaged with thorough knowledge of public programmes (Gomes, 2016), but above all the use of assessment methodologies which might give voice to *stakeholders* and take into consideration the *internal (i.e.,* the way companies organize their innovative practices) and *external (i.e.,* the economic, social, regional and sectorial conditions of the reality outside the company) dimensions that might condition their fulfillment (Bozeman, 2000).

A methodology was therefore designed and applied, encompassing all the agents involved in the process and striving to examine the quality and effectiveness of each step, for the sake of a successful innovation.

Through this Masters' research, the results are quite clear: collaborative R&D and technology transfer *(i)* allowed for a more thorough and detailed planning of the main tasks, methods and financial resources that are crucial for the development of technological solutions; *(ii)* fostered the improvement of the companies' capacities in their functional areas, by appointing highly qualified human resources, including the participation of PhD holders; *(iii)* were accomplished through the prior implementation of several activities of technoscientific dissemination (*e.g.* working-papers or science articles) and technological (*e.g.* international conferences or workshops); *(iv)* strengthened the desire for business expansion, through the establishment and/or extension of external partnerships and connections on a global level; and, furthermore, *(v)* focused more closely on the most critical European and national issues, such as energy efficiency, natural resources and health and well-being.

Nevertheless, it is known that innovating carries risks, since it is very difficult to anticipate the market's reaction to new technologies. Hence, by applying the IR methodology, it was quickly ascertained that the establishment of collaborative networks boosted the effectiveness of their innovation and market potential. It was observed that collaborative innovations are mostly aimed at growing and emerging markets, seeking new partners and fostering a larger and more active mobilization of potential *end-users*. However, at the end of the process, the lack of funding and the regulatory aspects proved to be the main obstacles to technology exploitation and commercialization.

Therefore, in order to tackle these concerns, these programmes and their instruments should be guided by the idea that, in addition to R&D activities aimed at advanced technologies, organizations have many other *inputs* that are equally relevant to the process of technology diffusion (*e.g.* product engineering, operations management and logistics, creativity management or design) and that must be considered simultaneously. Yet, those *inputs* are precisely the ones that have been excluded from innovation technology support policies and programmes.

It is imperative to correctly evaluate the way to go, contemplating the outreach of the abovementioned effects and transformations that are taking place in the national system: *(i)* firstly, the role of the innovators, in the industry and services, in assuring productivity and competitiveness, wherefore more attention will have to be given to the rise of new technology-based companies and to the convergence of both sectors of economic activity, regarding R&D; *(ii)* secondly, the role of innovation support agencies, which should stop functioning as mere community funds management offices and become closer to a diagnostic, monitoring and assessment services typology or to working as public consultants; *(iii)* thirdly, the role of intangible investment, which should give more attention to the flow of new knowledge, to the use of new procedures and to the fostering of new initiatives, where strategic thinking and action might be valued; *(iv)* fourthly, the role of public powers, as regulators and enablers of new methods and attitudes, through larger integration, on an operational level, in the management of different support programmes - a diffusion-centred policy; and *(v)* fifthly, the role of *end-users,* which tends to expand, for which reason more attention should be given to the mechanisms ruling technology exploitation, the pre-commercialization stage and the use of new knowledge and practices in the economy, as well as in society in general.

Evidently, these limitations translate into greater demands, regarding both the overhaul of the governance framework and the assessment of financial instruments, as well as the increase in responsibilities for the entities of R&D coordination and management. But these are pressing and indispensable measures in order to enable the qualitative leap that Portugal has been missing out on.

Genuine questions are thus raised concerning chiefly the capacity to continuously sustain the collective effort of companies and technology infrastructures. The accomplishment of this is dependent on an ongoing logic of dynamism and differentiation, through the use of already-existing infra-structures and the rearrangement of the papers of the institutional system's different actors, whilst prioritizing diversity as well as regional and sectorial specialization, as already begins to happen in terms of *policy-making* in Portugal (Santos, 2016).

6.2. Main constraints and future research perspectives

This study contributed to the robustness of policies assessment, through an enhanced *ex-ante* methodology (*i.e.,* more transparent and extensive) and the application of a holistic tool like IR. Incentives should thus be provided for future research which might bring progress to this research field, for instance through the implementation of these tools on other programmes and measures, the execution of comparative studies involving different techniques (Edler *et al.,* 2012) or the application of other methods focused on assessing the impact of the current policy instruments (Creswell, 2009).

Nevertheless, any research faces constraints in its application (Albarello *et al.,* 2011). The main constraint faced by this study involved the difficulties in applying the IR questionnaires to the realm of the Demonstrator projects, spread across the five NUTS II regions of Continental Portugal. Regarding the design stage of the *ex-ante* methodology, the difficulty was the establishment of the main assessment criteria. In this respect, the direct contact and counselling of several financial incentive's managers and of members of ANI's Administrative Board were paramount for the accomplishment of the task in question. Finally, there is the responsibility of creating a large database with official information from and for ANI, which operates, today as *hub* and public consultant of more than 50.0% of national companies.

All things considered, this research proposes **a system-oriented assessment methodology** to *economists* and *policy-makers*, one which might contribute to encourage the recurrent practice of policy assessment in Portugal and might also take the shape of a model that supports decision-making both in the design of new measures and in the execution of reformulations and adjustments in already-existing ones (Arnold, 2004).

In order to ensure the balance of the NIS, it is recommended that more encouragement is given to instruments promoting *technology transfer*, which undoubtedly entails the sharing of the existing deficit between all the economic agents comprising it. Moreover, initiatives aimed at creating the means to meet objective market needs should be prioritized, instead of actions that are restricted to the mere replacement of production equipment for technologically updated units. For this purpose, emphasis is laid on the decrease of entropy, so as to understand and make choices which lead to action (Christensen, 2010) and ultimately accelerate the knowledge-market process as well as the efficient provision of new technologies for the improvement of collective welfare in Portugal.

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APPENDICES

Appendix I – *New project Merit Referential* Model: *ex-ante* assessment

Project merit is calculated through the following rational:

$$\overline{Project\ Merit} = 0.3i + 0.2ii + 0.1iii + 0.1iv + 0.3v. \qquad (1)$$

The abovementioned rational includes ***five dimensions of analysis*** and each one of these dimensions has ***six selection criteria*** considered relevant for the development of innovation. Each criterion is scored in a scale of 1 to 5, with the *project merit*'s result being rounded to the 0.1 weighting factor.

More specifically, *project merit* is determined by using the following *dimensions of analysis*:

i. *Coherence and rationality*

This dimension is subdivided in *six selection criteria,* by taking into consideration the following rational:

$$\overline{Dimention\ \imath} = 0.1\boldsymbol{i_1} + 0.2\boldsymbol{i_2} + 0.1\boldsymbol{i_3} + 0.2\boldsymbol{i_4} + 0.2\boldsymbol{i_5} + 0.2\boldsymbol{i_6}. \qquad (10)$$

$\boldsymbol{i_1}$**.** Type of leading company

This criterion evaluates the type of leading company that invests in R&D and seeks to innovate. Its operationalization in four categories *"Microenterprise", "Small-scale enterprise, "Medium-scale enterprise"* and *"Large-scale enterprise"* comes from the categorization laid out in the *Oslo Manual* (OECD, 2018) – the *standard* manual for those who study or work in innovation.

A higher score (*i.e.,* 5) is given to the *"Microenterprise"* category, since these are very specialized companies in their sectors of performance, but usually less qualified and innovative (OECD, 2018). For this reason, the possibility of collaboration and interaction with other companies and/or technological infrastructures is very relevant, as it enables an effective exchange of specialized intellectual knowledge (Geroski, 1990; Lee *et al.,* 2010; Doh and Kim, 2014; McGuirk *et al.,* 2015). These companies also have higher economic-financial difficulties in investing in R&D, when compared with the other three categories (Scandura, 2016; Notification no. 04/SI/2017; Notification no. 05/SI/2017). On the other hand, Marcati *et al.* (2008) refer that big companies have internal funds and greater financial capability to lead R&D and innovation-based projects.

Moreover, already in 1942 Schumpeter defended that big companies had a higher internal R&D capacity and, as such, would be much more competitive (Schumpeter, 1982). Given the lesser need for R&D funding, a score of 1 or 2 is assigned to the *"Large-scale enterprise"* category, in accordance with the industry's level of technological intensity.

Type of leading company			
Micro-enterprise (1 to 9 employees)	Small-scale enterprise (10 to 49 employees)	Medium-scale enterprise (50 to 249 employees)	Large-scale enterprise (≥ 250 employees)
5	4	3	1/2

***i*₂.** Number of co-promoters

This criterion identifies the number of co-promoters involved in the R&D and innovation project. It includes four categories*: "One co-promoter", "Two co-promoters", "Three co-promoters"* and *"Four or more co-promoters"*. The higher the number of co-promoters, the greater the flow of ideas and technologies within the innovation process, thus contributing to a logic of constant interaction between all players involved, to the existence/reinforcement of *network* innovation and to the economic valuation of R&D (Debackere and Veugelers, 2005; Hu *et al.,* 2006).

Accordingly, a higher score (*i.e.,* 4/5) is given when the consortium involves four or more entities (enterprises or non-enterprises) of the innovation system and, conversely, a lower score is provided (*i.e.,* 1) when the project involves only one company.

Number of co-promoters			
One	Two	Three	Four or more
1	2	3	4/5

***i*₃.** Sector of activity

This criterion is divided in two categories of economic activity: *"Industry"* and *"Services",* similar to the categorization on the *CIS - Community Innovation Survey*.

According to the *Oslo Manual* (OECD, 2018), services that seek to innovate are usually linked to advanced technology sectors with higher R&D technological intensity (*e.g.* telecommunications, development of software, management informatics or robotics). Following this reasoning, a higher score is given to this sector of activity (*i.e.,* 4/5), although the R&D intensity of the technological sector itself should also be taken into consideration.

Sector of activity	
Industry	Services
2/3	4/5

i₄ Work plan

This criterion evaluates the congruence of the foreseen work plan, in particular the adequacy of the envisaged tasks according to their description, length and participants. The coherence of goals and deliverables is also analysed by taking into consideration their relevance and timing of availability. According to the Notifications no. 04/SI/2017 and no. 05/SI/2017, this criterion is subdivided into five categories, namely *"Weak/Non-existing information", "With some deficiencies", "Averagely devised", "Well-devised"* and *"Very well devised",* with different scores pertaining to the level of quality and organization, which vary between 1 and 5, respectively.

i₅ Scientific and technological methodology

This criterion assesses the technical quality of the proposed methodology for the project to implement the innovation, namely whether it complies with the scientific requirements of the sector under which the project will operate and whether it is technologically doable. According to the Notifications no. 04/SI/2017 and no. 05/SI/2017, this criterion is subdivided into five categories: *"Weak description", "Defective description", "Average description", "Good description"* and *"Excellent description",* all attaining different scores according to the level of scientific coherence and technological relevance, thus varying between 1 and 5, in conformity with the abovementioned order.

The i_4 and i_5 selection criteria are closely connected, technically depending on each other. Therefore, the score is provided in an integrated way.

		Work plan				
		Weak/Non-existing information	With some deficiencies	Averagely devised	Well-devised	Very well devised
Methodology	Weak description	1	1	1	1	2
	Defective description	1	1	2	2	3
	Average description	1	2	3	3	4
	Good description	1	2	3	4	4
	Excellent description	1	3	4	4	5

***i_6*. Investment plan**

This criterion evaluates the relevance of the financial resources involved in the process of innovation, taking into account the proposed goals. Five categories have already been created for the notifications no. 04/SI/2017 and no. 05/SI/2017.

These begin with the worst possible evaluation scenario: *"No information that allows for an evaluation of the sub criterion/Insufficient resources"*. The remaining criteria are as follows: *"Uneven resources, in need of considerable corrections", "Reasonable budget, in need of some corrections and better balancing of the cost structure", "Sustained budget, in need of minor adjustments and/or better balancing of the cost structure"* and *"Balanced and rightly sustained budget",* the most optimistic scenario. Scores vary between 1 and 5, according to the abovementioned criterion.

Investment plan				
No information that allows for an evaluation of the sub criterion/Insufficient resources	Uneven resources, in need of considerable corrections	Reasonable budget, in need of some corrections and better balancing of the cost structure	Sustained budget, in need of minor adjustments and/or better balancing of the cost structure	Balanced and rightly sustained budget
1	2	3	4	5

ii. Intensity and adequacy of R&D inputs

This dimension is subdivided in *six selection criteria,* by taking into consideration the following rational:

$$\overline{Dimention\ ii} = 0.2ii_1 + 0.2ii_2 + 0.1ii_3 + 0.1ii_4 + 0.2ii_5 + 0.2ii_6. \qquad (11).$$

***ii_1*. Parties involved**

This criterion refers to the type of entities involved in the R&D project. Bozeman (2000) and Arora and Gambardella (2001) point out the economic benefits that arise from the existence of collaborative innovation between technological infrastructures and companies (*e.g.* greater productivity, greater efficiency and cost reduction), particularly when it comes to R&D centres that are exclusively dedicated to highly technological scientific sectors, in which highly qualified specialists and experts collaborate with each other.

Amesse and Cohendet (2001) also demonstrate that empirical studies developed by universities usually pertain to recent technologies introduced in the market, thus promoting the reinforcement of skills and qualified and updated intellectual knowledge for the business world, as well as the hiring of students who daily construct and operate these technologies.

The relations between companies also promote a relatively open exchange of information, with the fluxes of information stimulating innovative activities (Romijn and Albaladejo, 2002; Laranja, 2007; Schot and Steinmueller, 2018) and encouraging the reduction of the risk associated with innovation (Tether, 2002). Their interactions allow companies to attain *inputs* (*e.g.* information on technologies, markets and other necessary *inputs* to the internal learning process) which the company would not be able to develop on its own (Edquist, 1997).

According to the review of economic literature conducted in Chapter 2 of the current thesis, collaborative R&D can, thus, occur between *"Companies or companies and non-profit organization"*, *"Companies and universities/polytechnic institutes"*, *"Companies and R&D Centres"* and *"Companies, universities/polytechnic institutes and R&D centres"* (Zuniga and Correa, 2013; Vásquez-Urriago *et al.,* 2016; Scandura, 2016; Binz and Truffer, 2017).

These can be defined as the four categories of the current *selection criteria,* which are scored according to the number and quality of potential benefits that come from each cooperation.

Parties involved			
Companies or companies and non-profit organization	Companies and universities/polytechnic institutes	Companies and R&D Centres	Companies, universities/polytechnic institutes and R&D centres
1/2	3	4	5

ii$_2$. Team's expertise

This criterion considers the composition of co-promoters' teams and values the existence of *core* competences regarding advanced scientific and technical knowledge. The scores, as defined by Notifications no. 04/SI/2017 and no. 05/SI/2017, represent an assessment of the teams' overall experience, thus connecting the teams of business entities with those of non-business-related entities, with a variation between 1 and 5 points.

<table>
<tr><td colspan="2"></td><td colspan="3">Curriculum and/or proved experience in R&D of business teams</td></tr>
<tr><td colspan="2"></td><td>Weak</td><td>Average</td><td>Strong</td></tr>
<tr><td rowspan="3">Curriculum and/or proved experience of non-business-related teams</td><td>Weak</td><td rowspan="3">1</td><td colspan="2">1</td></tr>
<tr><td>Average</td><td>3</td><td>4</td></tr>
<tr><td>Strong</td><td>4</td><td>5</td></tr>
</table>

Provided the project includes only one company or collaboration between business entities, the score assigned varies only between 1 (*i.e., "Weak"*) and 3 (*i.e., "Average"*), since the company or companies do not collaborate with any type of technological infrastructure.

R&D Curriculum of business teams		
Weak	Average	Strong
1	2	3

ii₃. Team's adequacy

This criterion evaluates the overall quality of the consortium and its ability to successfully develop the designated activities. For this purpose, the R&D teams' curricula is taken into consideration and is compared with the development of the proposed innovation, which can be labelled as *"Null", "Weak", "Average"* or *"Strong",* as was previously defined in the Notifications no. 04/SI/2017 and no. 05/SI/2017.

ii_4. Need to subcontract activities

This criterion evaluates the need to subcontract activities which are required for the development of the proposed innovation, with preference being given to the *inexistence of contracts external* to the project's team. This means that the team gathers all the necessary conditions and skills to fully develop the project.

Scores thus range between 1 and 5 points. If the team does decide to subcontract, it might occur in relation to *"Core activities"* or *"Accessory activities"*. The former would show that the team is under-qualified and unable to develop the proposed innovation by itself (*i.e.,* thus being scored with only 1 or 2 points).

			Adequacy of the consortium's team, given the project goals			
			Null	Weak	Average	Strong
Need to subcontract activities which are required for the development of the project	Yes	*Core* activities	1	2	2	2
		Accessory activities	1	2	3	4
	No		1	2	4	5

ii_5. Reinforcement of R&D and innovation capacity regarding new appointments

This criterion assesses the project's impact on the transfer of R&D competencies from business promotes, namely the transfer that results from hiring new highly qualified human resources (*i.e.,* with a degree or higher) for the development of innovative activities. According to the *International Standard Classification of Education* (*ISCED*), a graduated person has an *ISCED* level of *6*, thus the assessment of the effect of new appointments which hold a degree or higher is, in this case, provided by the following:

$$C\ Index = \frac{Number\ of\ people_{month}\ with\ ISCED\ level\ 6\ or\ higher\ to\ recruit\ for\ the\ project\ for\ R\&D\ activities}{Number\ of\ people_{month}\ allocated\ to\ the\ project} \times 100. \qquad (12)$$

ISCED	*Level of qualification*
(...)	*(...)*
6	*Degree*
7	*Masters*
8	*PhD*

***ii₆*.**Engagement of PhD holders

This criterion evaluates the contribution of the project to the strengthening business promoters' R&D skills, particularly through the hiring of PhD holders for the project team[70], as stated in Notifications no. 04/SI/2017 and no. 05/SI/2017.

It should be pointed out that individuals with higher levels of qualification are more capable and more likely to come up with and develop new technologies. Moreover, they gather better conditions for the exploitation of technological progress (Lundvall and Johnson,1994; Heirman and Clarysse, 2004). According to *ISCED*, a PhD holder has an *ISCED* level *8*. The assessment of the PhD holders' participation is ascertained through the following:

$$\textbf{\textit{D Index}}=\frac{\textbf{\textit{Number of people}}_{\textbf{\textit{month}}}\ \textbf{\textit{with ISCED level}}\ 8\ \textbf{\textit{allocated to the project}}}{\textbf{\textit{Number of people}}_{\textbf{\textit{month}}}\ \textbf{\textit{allocated to the project}}}\ \textbf{\textit{x 100.}} \qquad \textbf{\textit{(13)}}$$

The ***ii₅*** and ***ii₆*** selection criteria are rated together since they are intimately connected (*vide* Frascati Manual (OECD, 2017).

		Effect in terms of new appointments (C Index)		
		Low C Index ≤ 5	Average 5 < C Index ≤ 20	High C Index > 20
Engagement of PhD holders in project teams (D Index)	Low D Index ≤ 5	1	2	3
	Average 5 < D Index ≥ 20	2	3	4
	High D Index > 20	3	4	5

[70] The number of people_month corresponds to working hours in ETI (full-time equivalent).

iii. *Degree of novelty of innovation activities*

This dimension is subdivided into *six selection criteria,* by taking into consideration the following rational:

$$\overline{Dimention\ \boldsymbol{iii}} = 0.1\boldsymbol{iii}_1 + 0.1\boldsymbol{iii}_2 + 0.2\boldsymbol{iii}_3 + 0.1\boldsymbol{iii}_4 + 0.3\boldsymbol{iii}_5 + 0.2\boldsymbol{iii}_6. \qquad (14)$$

$\boldsymbol{iii_1}$. Type of innovation

According to Dosi (1988), Kovács (2000) and, more recently, Serrano and Neto (2018), business innovation can assume a triple dimension and be oriented towards the results of the innovation process – product innovation, process innovation and organizational innovation – which are core definitions of innovation typologies that can be found at the *Oslo Manual* (OECD, 2018).

"Product innovation" is focused on the development and improvement of the product's functions with the aim of introducing new or improved products in the market; *"process innovation"* is not limited to changes in equipment, also covering the organization of production and work, which are historically connected to technical changes. In addition, *"organizational innovation"* is the introduction of new management practices oriented towards new technologies, new administrative processes and the development of cooperation activities with other companies or technological competence structures.

Hölzl (2008) also adds that product innovation generates a competitive advantage through differentiation and process innovation is able to accomplish this advantage through costs reduction. Organizational innovation also contributes to product differentiation and/or costs reduction, although not directly.

Within this logic, this selection criterion includes the abovementioned three categories*,* which are scored according to the socioeconomic benefits that they generate (Call no. 57-A/2015).

$\boldsymbol{iii_2}$. Class of innovation

This criterion evaluates whether the demonstration of the proposed solution is a *"Radical", "Incremental"* or *"Non-existent"* novelty. By analysing the notion of innovation at a macro level, Freeman and Perez (1988) take into consideration two main levels: the *"Incremental",* when there are small changes in products or processes that allow for quality improvement or costs reduction and increase in productivity. These changes stem more from technology assimilation, compatibility between different equipment, learning efforts throughout the productive process (*i.e., "learning by doing"*), the use of products and the improvements that its users are capable of introducing (*i.e., "learning by using")*, as well as from the interaction with the suppliers (*i.e., "learning by interacting"),* than from a deliberate R&D effort.

"Radical" novelty is a discontinued process, usually a consequence of formal R&D efforts in companies laboratories, R&D centres and universities, which can originate a totally new market. Furthermore, the *"Non-existent"* category was added in order to classify 'comparable' novelties without technical and economical relevance.

In order to have an interactive evaluation, the abovementioned criteria ***iii***$_1$ and ***iii***$_2$ are scored together.

		Type of proposed innovation		
		Product innovation	Process innovation	(Technology-based) Organization innovation
Class of innovation	Non-existent	1		
	Incremental	3	3	2
	Radical	5	4	3

iii$_3$**.** Nature of the innovation

Schumpeter (1982) proposed a classification regarding the nature of the innovation, which is still used today in several empirical studies and referred to in the *Oslo Manual* (OECD, 2018). According to this author, innovation is the *"introduction of a new product", "qualitative improvement of an existing product", "introduction of a new method of production", "improvement of an existing production method", "opening of a new market", "introduction of new sources of input supply" and "changes in the organizational structure".* All these criteria are treated and scored according to Schumpeter's evaluation model, of seven evaluation criteria for the nature of the innovation.

Nature of the innovation						
Changes in the organizational structure	Introduction of new sources of input supply	Opening of a new market	Improvement of an existing production method	Qualitative improvement of an existing product	Introduction of a new production method	Introduction of a new product
1	2	3	3	4	4	5

iii$_4$. Technological field

The entity that coordinates and manages the measures and instruments within the scope of the SI R&D – *ANI* – is divided into five scientific and technological thematic areas that represent the five categories of this criterion. These are *"ICT, instruments and robotics", "Mechanics and energy", "Chemistry", "Materials and construction"* and *"Biotechnology and agro-sciences"* (Notification no. 04/SI/2017; Notification no. 05/SI/2017). Their score is based on Portugal 2020's priority areas.

Technological field				
Biotechnology and agro-sciences	Materials and construction	Chemistry	Mechanics and energy	ICT, instruments and robotics
2	3	4	4	5

iii$_5$. R&D technological intensity

The *Frascati Manual* (OECD, 2017) distinguishes industries according to their R&D technological intensity, setting forth the significant differences that exist between them. It should be noted that R&D intensity stems from R&D prevision of costs as part of the total production (OECD, 2017). This selection criterion focuses on the four categories defined by the Manual: *"Low-intensity technology", "Medium-low intensity technology", "Medium-high intensity technology"* and *"High-intensity technology"*, scored between 2 and 5 points.

R&D technological intensity			
Low-intensity technology	Medium-low intensity technology	Medium-high intensity technology	High-intensity technology
2	3	4	5

iii$_6$. Degree of technological complexity

This criterion assesses the level of technical and scientific complexity in order to reach innovation. The scores variation depends on the number of tasks, the way of accomplishing them (*i.e.,* methods and techniques), as well as the number of entities involved in them and the efficiency with which they seek to deliver them, in comparison with the proposed goals and the obstacles previously identified in the project. As such, this criterion can be categorized as *"Low", "Average"* and *"High"* and its scores vary between 1, 3 and 5, respectively.

Degree of technological complexity		
Low	Average	High
1	3	5

iv. The scope of R&D outputs and diffusion

This dimension is subdivided in *six selection criteria,* by taking into consideration the following rational:

$$\overline{Dimention\ iv} = 0.1\boldsymbol{iv_1} + 0.1\boldsymbol{iv_2} + 0.1\boldsymbol{iv_3} + 0.2\boldsymbol{iv_4} + 0.2\boldsymbol{iv_5} + 0.3\boldsymbol{iv_6}. \quad (15)$$

iv₁. Intellectual property registration

This criterion attempts to assess the existence (or not) of intellectual and industrial property rights registration and requests by the entities involved in the R&D project. According to article 61st of the Call no. 360-A/2017, the following intellectual and industrial property registrations and requests are eligible: *(i)* national patent, trademark, utility model, design or model registration or request presented at the National Industrial Property Institute (INPI), *(ii)* patent, trademark, utility model, design or model registration or request presented abroad but through the respective national administrations, claiming (or not) a Portuguese priority, *(iii)* European patent registration or request presented at the INPI or at the European Patents Organization, as long as it claims a Portuguese patent or utility model request as priority, *(iv)* international patent registration or request presented at the INPI or at the European Patents Organization, as long as it claims a Portuguese patent or utility model request as a priority, or *(v)* a communitarian design or model request presented at the Internal Market Harmonization Institute.

		Quantity		
		None	One	More than one
Patents request of registration	No	1		
	Yes		3	5

iv₂. Type of protection *(in the case of request or registration)*

This criterion aims to assess the intellectual and industrial property rights typology to which the parties involved in the project have already applied. The type of protection also encompasses the scope of the protection, in order to make a more comprehensive analysis. As such, the categories are: *"Patent", "Trademark", "Utility model" and*

"Design" registered or to be registered on a *"National"* or *"European/International"* scope. The scores provided are based on the notification no. 23/SI/2017.

		Scope	
		National	European/International
Type of protection	Patents	4	5
	Trademark	3	4
	Utility model	3	4
	Design	4	5

***iv_3*.**Positive externalities

This criterion assesses the envisaged capacity of the project to generate positive externalities for the economy, thus valuing the incidence on intermediate products and services for companies. It is considered a process when the technology taker (*i.e.,* the companies) does not take part as leader of the project but only as project partner (as indicated in the consortium contract) (Notification no. 04/SI/2017, Notification no. 05/SI/2017).

Positive externalities		
Process	Consumer goods	Intermediate product
1	3	5

***iv_4*.** Effects of dissemination and promotion

This criterion evaluates the management of the acquired knowledge regarding the dissemination and promotion of results. It is important to take into consideration that the relations between science and economy have become progressively closer and, as a consequence, science tends to be more and more restrained and supported by purely economic goals. Therefore, dissemination is the process of spreading innovation among a population of potential users.

Innovation dissemination and promotion are crucial steps for the success of innovation (Mintrom, 1997; Caraça, 2003). Taking this into account, this criterion presents two main categories: the existence of dissemination (*i.e., "Yes"*), that materializes in three subcategories: *"Entails technology diffusion", "Entails* *technoscience diffusion”* and *“Entails technology and technoscience diffusion”*, and the inexistence of dissemination (*i.e., “No”*), representing the lowest score of 1 point.

$\boldsymbol{iv_5}$. Economic valorization of results

This criterion aims to assess the management of the acquired knowledge and its potentialities regarding the quality of the valorization plan of innovative results in companies, since this is one of the main priorities of the innovation process under the current Framework for innovation support and public policy design and implementation. As such, this criterion considers two impartial categories: “*The plan entails only stand-alone activities of diffusion and dissemination of results”* and *“The plan presents consistency with the foreseen activities, with a great potential for the dissemination of results”*.

<table>
<tr><td colspan="3"></td><td colspan="2">Economic valorization of results</td></tr>
<tr><td colspan="3"></td><td>Plan with stand-alone activities of diffusion and dissemination of results</td><td>Plan presents consistency with foreseen activities, with great potential for the dissemination of results</td></tr>
<tr><td rowspan="4">Wide dissemination and promotion efforts</td><td rowspan="3">Yes</td><td>Entails technology diffusion</td><td>2</td><td>3</td></tr>
<tr><td>Entails technoscience diffusion</td><td>3</td><td>4</td></tr>
<tr><td>Entails technology and technoscience diffusion</td><td>4</td><td>5</td></tr>
<tr><td colspan="2">No</td><td colspan="2">1</td></tr>
</table>

$\boldsymbol{iv_6}$. Technology transfer intensity

This criterion attempts to evaluate the R&D project in terms of technology transfer. For this purpose, an assessment is conducted of the development of synergies that allow for a smart, sustainable and inclusive growth, anchored on a collaborative strategy and of ongoing interaction through the *knowledge triangle* (*i.e.,* education, research and innovation).

It also aims to assess the link between the production of knowledge and companies, as well as the incentive given to the development of entrepreneurship, visible in each project. Therefore, this criterion is operationalized in three categories*: “Reduced technology transfer intensity”, “Average technology transfer intensity”* and *“High* *technology transfer intensity"*, scored as 1, 3 and 5, respectively, based on the intensity with which they cooperate with other parties of the innovation system.

Technology transfer intensity		
Reduced technology transfer intensity	Average technology transfer intensity	High technology transfer intensity
1	3	5

***v.**Impact on business competitiveness and national economy*

This dimension is subdivided in *six selection criteria,* by taking into consideration the following rational:

$$\overline{Dimention\ \boldsymbol{v}} = 0.2\boldsymbol{v}_1 + 0.1\boldsymbol{v}_2 + 0.1\boldsymbol{v}_3 + 0.2\boldsymbol{v}_4 + 0.2\boldsymbol{v}_5 + 0.2\boldsymbol{v}_6. \quad (16)$$

$\boldsymbol{v}_1$**.** Business strategy

This criterion assesses the importance of the project in the strategy of the leading or of the company that offers to value the project results. Projects with higher potential impact regarding business diversification are valued the most (*i.e.,* access to new markets or customers' segments). Therefore, this criterion can be categorized in four possible answers: *"With no impact/No information available to assess this criterion", "Expansion of the current business, in order to improve process efficiency", "Expansion of the current business, in order to enrich the current supply or reach new customer segments"* and *"Expansion of the current business, in order to enrich the current supply and reach new customer segments".* Scores vary between 1,3, 4 and 5 points.

Business strategy			
With no impact/No information available	Expansion of the current business, improving process efficiency	Expansion of the current business, enriching the current supply or reaching new customer segments	Expansion of the current business, reaching new customer segments and new markets
1	3	4	5

$\boldsymbol{v}_2$**.** Propensity for international markets

This criterion intends to assess the contribution of the project for the increase of the co-promoter's international competitiveness, thus valuing not only the creation of products, processes or services susceptible to being exported, but also the capacity to access those international markets. Hence, this criterion evaluates the exportable nature – *"Yes, of little relevance to the company(ies) strategic guidelines", "Yes, relevant to the* *company(ies) strategic guidelines"* or *"No"* – as well as the *existence of international partners or other agents that facilitate access or presence at foreign markets.*

		Export channels		
		No	Yes	
			Little relevance to the company(ies) strategic guidelines	Relevant to the company(ies) strategic guidelines
The co-promotors have established export channels /Existence of international partners and/or other agents that facilitate access or presence at foreign markets	Yes	1	2	4/5
	No	1	2	3

***v*₃.** Contribution to national economy

This criterion of a quantitative nature aims to assess the Gross Value Added (GVA) that project leaders envisage achieving by investing in their R&D and innovation project. This is mainly a forecast of the final result of the productive activity carried out for 18 months, which results from the difference between the production value and the intermediate consumption value (Notification no. 04/SI/2017; Notification no. 05/SI/2017). Moreover, this criterion takes into consideration R&D expense and dimension of the company to invest.

Contribution to National economy		
Low	Average	High
1	3	5

***v*₄.** Post-project investment on R&D

This criterion assesses whether the project contributes to the result indicator *Post-project investment on R&D (as part of the GVA).* Project leaders with higher R&D intensity and those who contribute the most to increase R&D expenditure are valued.

Therefore, *for companies with R&D expenses prior to the start of the project,* the project is scored according to the following matrix:

		Companies R&D expenses as part of the VAB (Index P)		
	Micro or Small-sized enterprises	P < 0.8%	0.8 % ≤ P < 1.0%	P ≥ 1.0 %
	Medium or Large-scale enterprises	P < 1.8%	1.8% ≤ P < 2.0%	P ≥ 2.0 %
R&D increase between project start and finish	Yes	3	4	5
	No	2	3	4

For companies with no foreseen expenses before the start of the project, the project is scored according to the following matrix:

	Companies R&D expenses as part of the VAB (P Index)		
Micro or Small-sized enterprises	P < 0.8 %	0.8 % ≤ P < 1.0 %	P ≥ 1.0%
Medium or Large-scale enterprises	P < 1.8 %	1.8% ≤ P < 2.0 %	P ≥ 2.0 %
Score	2	3	5

Considering that:

$$\boldsymbol{P\ Index} = \frac{\boldsymbol{post\text{-}project\ beneficiary\ investment\ on\ R\&D}}{\boldsymbol{post\text{-}project\ beneficary\ VAB}} \mathbf{x\ 100.} \qquad \textit{(17)}$$

Note: If the project leads to positive externalities in other thematic domains that were approved by European funds (*e.g.* social inclusion and labour, human capital and sustainability, and efficiency in the use of resources), there's an increased score of 0.5 points. However, the score result assigned to criterion $\boldsymbol{v_4}$ cannot exceed 5 points.

$\boldsymbol{v_5}$**.** Contribution to the National Smart Specialization Strategy (ENEI)

This criterion evaluates the impact of the project regarding Portugal 2020's thematic domains, through the degree of alignment with the *National Smart Specialization Strategy (ENEI)*. The strategy's vision for 2020 aims at a more competitive, creative and internationalized Portugal, with an economy grounded on technology-intensive tradable goods and services, through the strengthening of the research capabilities and synergies between actors of the NIS. The smart strategic priorities combine the competitive and comparative advantages with those in which Portugal has growth potential (Call no. 360-A/2017).

National and regional diagnoses have been able to identify the economic sectors, scientific domains and technologies in which Portugal is, or can become, competitive. These are a direct result of the combination of existing capacities and potentials in terms of the productive structure and *core* scientific knowledge of the country, as well as of the alignment with EU priorities for the 2014-2020 programming period (Serrano and Neto, 2018).

The themes identified are organised in five thematic units that present common logics. Their aggregation comes from the close relations that exist between each cluster. The *five thematic units* are the following:

Thematic unit 1 – *Transversal technologies and their applications*

Energy – production and energy transport optimization and complementarity in its management; final energy use; energy efficiency and its impacts; new technology applications and intelligent energy networks; European energy market integration.

ICT – promotion of the internet of the future; electronic-based infrastructures; modelling and simulation software; components and sensors engineering; new digital business models; mobile applications.

Raw materials and materials – development of innovative technologies for sustainable mineral resources; sustainable production of raw materials and forest-based materials; application of new advanced technologies to raw materials and materials; application of new materials to traditional industries.

Thematic unit 2 – *Production industries and technologies*

Production technologies and product industries – increase in process industries' competitiveness; green chemistry; pharmaceutical industry.

Production technologies and process industries – promotion of sustainable industrial growth grounded on highly value-added products and technological content; factories of the future.

Thematic unit 3 – *Mobility, space and logistics*

Automobile, aeronautics and space – automobile production and of its components sustainability and product innovation; development of advanced technologies applied to the automobile industry, aeronautics and space; development of the components industry; knowledge-intensive services; development of subsystems for the aeronautics and space industry.

Transports, mobility and logistics – management of port infrastructures; development of new sustainable transport of goods; safe and sustainable transports; smart transports systems and logistics; standardization and certification; new transport public policies.

Thematic unit 4 – *Natural resources and environment*

Agro-food – healthy food production based on sustainable agriculture; eco-systemic organization of rural areas; food engineering and advanced technologies; wine; exploiting the links between health, sea economy and tourism.

Forest – eco-systemic development of the forest; sustainable production of raw materials and forest-based products.

Sea economy – technological development of sea fishing; fight against pathogenic organisms and diseases; forecast and modelling capability and analysis of population dynamics; development of innovative solutions adapted to the sea economy; geophysical and ecological reality of the Portuguese shore.

Water and environment – hydric resources; waste; soils; and ecosystems.

Thematic unit 5 – *Health, well-being and territory*

Health – ageing and active life; diseases; biomaterial and nanomedicine; medical technologies.

Tourism – exploring the cultural heritage; diversification of the tourism offers and associated services; integration in the tourism value chain.

Cultural and creative industries – valorization of products and spaces; production, distribution and promotion of cultural and creative content; digital contents and software services.

Habitat – new methods of sustainable and efficient production; development of materials and innovative application.

Taking this into consideration, this criterion assesses the project's alignment with the above-mentioned units, according to the following matrix:

Inclusion in domains of smart specialization		
Degree of inclusion	Classification	
Null	1	No inclusion in ENEI's specialization domains
Low	3	Inclusion in one of ENEI's specialization domains
Average	4	Inclusion in two of ENEI's specialization domains
Strong	5	Inclusion in more than two of ENEI's specialization domains

v_6. Regional and sectorial convergence

This criterion assesses the project's impact on regional and sectorial competitiveness by taking into consideration the scope of the defined domains and the alignment with the *Regional Smart Specialization Strategy (EREI)*. Each NUTS II has a specific matrix.

It should be pointed out that a project located in more than a NUTS II region will be scored in terms of the location that gathers the greater amount of eligible investment.

In case a project is aligned with only one domain, it is assigned a *"Low"* degree of alignment; if it is aligned with two domains it scores an *"Average"* degree of alignment; and if it is aligned with three or more domains, it receives a score of *"High"* degree of alignment (Call no. 360-A/2017).

NUTS II North

Core domains: *"Culture, creation and fashion"*, *"Mobility and environment industries"*, *"Agro-environmental systems and food"* and *"Advanced systems of production"*.

Emergent domains: *"Health and life sciences"* and *"Symbolic capital, technologies and tourism services"*.

Wild-card domains: *"Sea resources and economy"* and *"Human capital and specialized services"*.

NUTS II Centre

Core domains: *"Sustainable industrial solutions"* and *"Valuation of endogenous natural resources"*.

Emergent domains: *"Technologies for the quality of life"* and *"Territorial innovation"*.

Wild-card domains: *"Energy efficiency"*, *"Territorial cohesion"* and *"Internationalization"*.

NUTS II Lisbon

Core domains: *"Research, technology and health services"*, "*Knowledge, prospection and marine resources"*, *"Tourism and hospitality"*, *"Mobility and transport"* and *"Creative media and cultural industries"*.

Emergent domains: *"Advanced services for companies"*.

Wild-card domains: *"Market services with strong knowledge intensity"*.

NUTS II Alentejo

Core domains: *"Food and forest"*, *"Mineral, natural and environmental resources economics"* and *"Heritage, cultural and creative industries and tourism services"*.

Emergent domains: *"Critical technologies, energy and smart mobility"*.

Wild-card domains: *"Social economy technologies and specialized services*".

NUTS II Algarve

Core domains: *"Tourism"* and *"Sea"*.

Emergent domains: *"Agro-food, agro-processing, forest and green biotechnology"*, *"ICT and creative and cultural industries"* and "*Renewable energies"*.

Wild-card domains: *"Health, well-being and life sciences"*.

		Scope of the defined domains			
		Core	Emergent	*Wild-card*	Not framed
Degree of alignment	Low	3.0	3.0	3.0	2.5
	Average	4.5	4.0	3.5	2.5
	High	5.0	4.5	4.0	2.5

Appendix II – *Innovation Radar* questionnaire: *ad-interim/ex-post assessment*

1) Title of the innovation

2) Describe the innovation (in less than 500 characters, spaces included):

3) Is the innovation developed within the project…:
a) Under development
b) Already developed but not yet being exploited
c) Being exploited

4) Characterize the type of innovation
a) Significantly improved product
b) Significantly improved service (except consulting services)
c) Significantly improved process
d) Significantly improved marketing method
e) Significantly improved organizational method
f) Consulting services
g) New product
h) New service (except consulting services)
i) New process
j) New marketing method
k) New organizational method
l) Other

5) Level of innovation: What is the level of innovation?
a) Some distinct, probably minor, improvements over existing products
b) Innovative but could be difficult to convert customers
c) Obviously innovative and easily appreciated advantages to customer
d) Very innovative

6) How will the innovation be exploited?
a) Introduced as new to the market (commercial exploitation)
b) Only deployed as new to the organization/company (new internal processes implemented, etc.)
c) No exploitation planned

7) ***Indicate the step(s) in order to bring the innovation to (or closer to) the market***

	Done or ongoing	***Planned***	***Not Planned but needed/desirable***	***Not planned and not needed***
1. Technology transfer				

2. A partner's research team and business units are both engaged in activities relating to this innovation				
3. Market study				
4. Prototyping in laboratory environment				
5. Prototyping in real world environment				
6. Pilot, Demonstration or Testing activities				
7. Feasibility study				
8. Launch a start-up or spin-off				
9. Licensing the innovation to a 3rd party				
10. Complying with existing standards				
11. Contribution to standards				
12. Raise capital				
13. Raise funding from public sources				
14.Business Plan				
15. Other (please specify)				

8) ***Is there a clear owner of the innovation in the consortium or multiple owners?***
   a) One clear owner
   b) Multiple owners

9) ***Indicate (up to a maximum of 3) key organization(s) delivering this innovation. For each of these identify under the next question their needs to fulfil their market* potential**
   Organization 1:
   Organization 2:
   Organization 3:

10) ***Indicate their needs to fulfil their market potential***

	Organization 1	***Organization 2***	***Organization 3***
1. Investor readiness training			
2. Investor introductions			
3. Biz plan development			
4. Expanding to more markets			
5. Legal advice (IPR or other)			
6. Mentoring or Coaching			
7. Partnership with other SME(s)			
8. Partnership with large corporates			
9. Incubation/Startup accelerator			
10. Executive Training Other			
11. Other (specify)			

11) ***For the private company/companies chosen as one of the 3 "key innovators", will this innovation be used by mainly current or new customers?***
   a) Current customers
   b) New customers

12) ***Market maturity: The market targeted by this innovation is ...***
   a) The market is not yet existing and it is not yet clear that the innovation has potential to create a new market
   b) Market-creating: The market is not yet existing but the innovation has clear potential to create a new market
   c) Emerging: There is a growing demand and few offerings are available
   d) Mature: The market is already supplied with many products of the type proposed

13) ***Market dynamics: is the market…***
   a) In decline
   b) Holding steady
   c) Growing

14) Are there other markets for this innovation that the innovators are not yet targeting?
a) Yes
b) No

15) Market competition: How strong is competition in the target market?
a) Patchy, no major players
b) Established competition but none with a proposition like the one under investigation
c) Several major players with strong competencies, infrastructure and offerings

16) When do you expect that such innovation could be commercialized (from today)?
a) Less than 1 year
b) Between 1 and 3 years
c) Between 3 and 5 years
d) Between 5 and 10 years
e) More than 10 years

17) When do you expect that such innovation could be commercialized (from today)?
a) Yes
b) No

General Questions

1) How do you consider the project's performance in terms of innovation?
a) Performing below my expectations
b) Meeting my expectations
c) Exceeding my expectations
d) Highly exceeding my expectations

2) How does the innovator engage End-users?
a) End-users are actively engaged in co-creating the innovation(s)
b) No End-users consulted or engaged in innovation(s) development
c) End-users are consulted (e.g. in testing activities)

3) Are there IPR issues within the consortium that could compromise the ability of the organization(s) to exploit new products/solutions/services, internally or in the market place?
a) Yes
b) No

4) Which are the external bottlenecks that compromise the ability of project partners to exploit new products, solutions or services, internally or in the market place?
a) Regulation
b) Skills in the wider workforce
c) Standards
d) Financing
e) Trade issues (between MS, globally)
f) IPR
g) Others

5) Indicate how many patents have been applied for by the project: _________

6) How would you rate the level of commitment of relevant organization(s) to exploit the innovation?
a) Very low
b) Low
c) Average
d) High
e) Very high

7) ***Please indicate the 1 partner (excluding large enterprises) that the panel considers to be the most impressive in terms of innovation potential within the context of the innovations identified***

8) ***Please provide concrete recommendations for the project to improve its innovations and their potential to deliver impact in - or close to - the market place.***

9) ***Hypothetically but honestly, would you invest your own money in any innovation developed by this project?***
   a) Yes
   b) No

10) ***Please indicate the participant(s) from which a woman is in a position of leadership (such as Principal Investigator / Work Package Leader) for this project:***

Appendix III – Matching survey questions with assessment criteria: *ad-interim/ex-post assessment*

Innovation potential assessment framework

Criteria and questions		***Scoring***
Innovation Readiness	**Question code***	**Max: 5**
Development phase	Q3	
Under development	a	0
Developed but not exploited	b	0.25
Being exploited	c	0.5
Time to market	Q16	
Less than 1 year	a	1
Between 1 and 3 years	b	0.75
Between 3 and 5 years	c	0.5
Between 5 and 10 years	d	0.25
More than 10 years	e	0
Technology transfer	Q7.1	
Done		0.5
Planned		0.25
Prototyping in laboratory environment	Q7.4	
Done		0.5
Planned		0.25
Prototyping in real world environment	Q7.5	
Done		0.5
Planned		0.25
Pilot, Demonstration or Testing activities	Q7.6	
Done		0.5
Planned		0.25
Feasibility study	Q7.7	
Done		0.5
Planned		0.25
Complying with existing standards	Q7.10	
Done		0.5
Planned		0.25
Contribution to standards	Q7.11	
Done		0.5
Planned		0.25

Criteria & questions		***Scoring***
Innovation Management	**Question code***	**Max: 5**
There is a clear owner of the innovation	Q8	
One clear owner	a	0.5
Multiple owners	b	0.25
A partner's research team and business units are both engaged in activities relating to this innovation	Q7.2	
Done		0.5
Planned		0.25
Market study	Q7.3	
Done		0.5
Planned		0.25
Launch a start-up or spin-off	Q7.8	
Done		0.5
Planned		0.25
Licensing the innovation to a 3rd party	Q7.9	
Done		0.5
Planned		0.25
Raise capital	Q7.12	
Done		0.5
Planned		0.25
Raise funding from public sources	Q7.13	
Done		0.5
Planned		0.25
Business plan	Q7.14	
Done		0.5
Planned		0.25
Are there IPR issues within the consortium that could compromise the ability of the organization(s) to exploit new products, solutions, services, internally or in the market place?	GQ3	
Yes	a	0
No	b	1

*GQ refers to general questions in the questionnaire

*GQ refers to general questions in the questionnaire

Criteria and questions		*Scoring*
Market Potential	**Question code***	**Max: 5**
Type of innovation:	Q4	
New product, process or service	g OR i OR h	0.55
Significantly improved product, process or service	a OR c OR b	0.40
New marketing or organizational method	j OR k	0.25
Significantly improved marketing or organizational method	d OR e	0.10
Consulting services, other	f OR l	0
Level of innovation: What is the level of innovation	Q5	
Some distinct, probably minor, improvements over existing products.	a	0.25
Innovative but could be difficult to convert customers.	b	0.40
Obviously innovative and easily appreciated advantages to customer	c	0.55
Very innovative	d	0.70
Innovation exploitation:	Q6	
Commercial exploitation	a	0.5
Internal exploitation	b	0.25
No exploitation	c	0
Market maturity: The market for this innovation is…	Q12	
The market is not yet existing…	a	0
Market-creating: …	b	0.25
Emerging: …	c	0.75
Mature: …	d	0.50
Are there other markets for this innovation …	Q14	
Yes	a	0.25
No	b	0
Market competition: How strong is competition in the target market?	Q15	
Patchy, no major players	a	0.75
Established competition but none with a proposition like the one under investigation	b	0.50
Several major players with strong competencies and infrastructure	c	0
Has a trademark been registered for this innovation	Q17	
Yes	a	0.25
No	b	0
Number of patents that have been applied by the project	GQ5	
0		0
1		0.25
2-3		0.50
>3		0.75
Number of external bottlenecks that compromise the ability of project partners to exploit new products, …	GQ4	
0		0.50
1		0.30
2		0.15
>2		0

*GQ refers to general questions in the questionnaire

Innovator capacity assessment framework

Criteria and questions		***Scoring***
Innovator's Ability	**Question code***	**Max: 5**
Number of innovations in the project for which an organization is identified as a key organization(s) in the project delivering this innovation	Q10	
1		0.25
2		0.50
3		1
Max score of innovation for which an organization is identified as a key organization(s) in the project delivering this innovation	Output of the innovation assessment framework	Score between 0-1
Organization is considered as the most impressive in terms of innovation potential	GQ7	1
Total number of the organization's needs to fulfil the market potential of an innovation	Q10	
No needs		1
Between 1 and 2		0.75
Between 3 and 4		0.5
Between 5 and 6		0.25
More than 6		0
This innovation will be used by mainly	Q11	
Current customers	a	0.5
New customers	b	1

*GQ refers to general questions in the questionnaire

Criteria & questions		***Scoring***
Innovator's Environment	**Question code***	**Max: 5**
The engagement of end-users in the consortium	GQ2	
End-users are actively engaged	a	1
End-users are consulted	b	0.5
No end-users consulted or engaged in innovation(s) development	c	0
The project performance in terms of innovation	GQ1	
Meeting expectations	b	0.25
Exceeding expectations	c	0.5
Highly exceeding expectations	d	1
The level of commitment of relevant partners to exploit the innovation	GQ6	
Very high or high	d OR e	2/1
Average	c	0.5
Below average	a OR b	0
Hypothetically, the reviewer would invest in an innovation developed by this project	GQ9	
Yes	a	1
No	b	0

*GQ refers to general questions in the questionnaire

Appendix IV – *Ex-ante* assessment: scores achieved by the Demonstrators, in accordance with the *New referential* (Part I)

Demonstrator projects	***Coherence and rationality***						***Intensity and R&D inputs***						***Degree of novelty of innovation activities***						***Scope of R&D outputs and diffusion***						***Impact on business competitiveness and economy***					
	i_1	i_2	i_3	i_4	i_5	i_6	ii_1	ii_2	ii_3	ii_4	ii_5	ii_6	iii_1	iii_2	iii_3	iii_4	iii_5	iii_6	iv_1	iv_2	iv_3	iv_4	iv_5	iv_6	v_1	v_2	v_3	v_4	v_5	v_6
Coopweld	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	1		5	5	5	3	5	5	5	5	4	5
WGR	4	1	5	4	4	5	1	3	2	2	5	5	3	3	4	5	5	5	3	5	5	5	5	1	5	5	3	4	4	5
Breath2Seat	3	2	3	4	4	3	4	3	3	3	5	5	3	3	4	4	4	3	3	4	3	1	1	3	4	2	5	5	3	3
Prodiam	3	2	3	4	4	4	3	5	5	5	3	3	3	3	4	4	4	3	1		5	4	4	3	4	5	3	5	4	4.5
CerWave	3	3	3	4	4	4	4	5	5	5	5	5	5	5	5	4	4	3	3	4	5	4	4	3	4	2	1	3	5	4.5
Lamitech	2	1	3	2	2	3	1	3	3	3	3	3	4	4	2	2	2	1	1		1	1	1	1	3	4	3	3	5	4.5
AIMS2	5	3	5	3	3	4	5	5	5	5	1	1	5	5	5	5	5	5	1		5	3	3	5	5	5	5	5	3	3.5
Revifeel Plus	3	2	3	4	4	4	4	3	4	4	2	2	3	3	3	3	3	3	3	4	1	5	5	3	3	5	3	4	3	4.5
Shopview2market	3	3	5	2	2	2	4	3	2	2	3	3	3	3	3	5	5	5	3	3	1	4	4	3	5	2	3	4	4	4.5
Peddir	4	3	5	3	3	3	3	5	5	5	5	5	4	4	2	5	5	5	3	4	1	5	5	3	5	5	5	5	4	4
HBios Demo	5	2	4	5	5	4	1	3	3	3	2	2	3	3	4	2	2	1	1		3	3	3	1	3	2	3	4	3	3
Safe	5	1	3	5	5	5	1	3	5	5	3	3	3	3	3	5	5	5	1		1	2	2	1	5	1	5	5	5	4.5
Validata	2	1	5	5	5	5	1	3	5	5	4	4	2	2	1	5	5	5	1		1	3	3	1	3	4	5	5	5	4.5
Flexstone	2	5	3	4	4	4	4	3	4	4	2	2	4	4	2	5	5	5	3	4	1	5	5	3	5	5	5	5	5	4.5
Algaecoat	3	2	3	4	4	4	3	3	4	4	5	5	4	4	2	2	2	1	3	4	1	4	4	3	5	5	5	5	5	4.5
NedDisplay	5	1	4	4	4	5	3	5	4	4	2	2	3	3	4	5	5	5	3	5	5	5	5	3	5	5	3	3	5	5
Asic Tofpet 2	5	1	5	3	3	3	1	3	2	2	5	5	3	3	3	5	5	5	1		5	4	4	1	5	4	5	4	3	3
Cork.a.tex-yarm	2	5	3	4	4	4	5	5	3	3	2	2	3	3	3	4	4	3	3	4	1	5	5	5	5	5	5	5	5	5
Sidenav	3	5	3	4	4	4	4	5	5	5	4	4	3	3	4	5	5	5	3	5	5	5	5	3	4	5	1	3	4	4.5
DNArterialDecoder	4	2	5	3	3	3	4	3	4	4	5	5	5	5	5	4	4	3	3	5	5	3	3	3	4	1	3	5	4	4
DEMO@Polyfenton	4	2	3	5	5	5	3	5	5	5	3	3	4	4	2	4	4	1	3	4	1	5	5	3	3	5	5	5	5	5
MediTube	1	1	3	4	4	5	1	2	2	2	2	2	3	3	4	4	4	1	5	5	5	3	3	1	4	2	3	3	4	4.5
Celsmart Sense	2	2	4	3	3	5	4	5	4	4	5	5	4	4	4	4	4	1	5	5	1	5	5	3	5	5	5	5	5	4.5
DemoExp	5	1	2	3	3	5	1	3	2	2	4	4	3	3	4	4	4	3	3	5	5	5	5	1	5	4	5	4	3	5
CallScriber	4	1	4	4	4	5	1	3	2	2	1	1	3	3	2	5	5	5	1		1	3	3	1	4	2	4	5	4	4.5
Sei	4	1	4	3	3	3	1	2	2	2	2	2	4	4	3	5	5	5	1		1	4	4	1	5	4	3	3	3	4.5
Ship	2	4	3	3	3	4	4	3	3	3	3	3	3	3	3	4	4	3	1		1	5	5	3	5	5	5	5	4	4.5
LedinTex	4	2	3	3	3	3	4	3	2	2	4	4	5	5	5	5	5	5	3	3	3	5	5	3	5	5	5	5	5	5
DEM@Biofumados	4	2	3	3	3	3	3	3	4	4	3	3	4	4	4	2	2	1	1		1	4	4	3	3	2	5	5	5	5
Netefficity	4	2	5	3	3	4	3	3	2	2	2	2	3	3	2	5	5	5	5	4	5	5	5	3	4	2	3	4	5	4
Magline	3	4	3	5	5	4	4	3	3	3	2	2	4	4	4	4	4	1	3	3	1	5	5	3	3	5	5	5	5	4.5
P4sert	2	2	3	2	2	3	2	3	2	2	3	3	5	5	5	4	4	1	3	4	3	2	2	3	5	5	1	3	4	3.5
Walkon Demo	4	2	5	4	4	3	4	3	4	4	2	2	3	3	4	4	4	1	1		3	2	2	3	5	5	3	4	4	5
Fermalg	3	1	2	4	4	4	1	2	2	2	4	4	3	3	3	2	2	1	1		1	5	5	1	3	2	5	5	5	5
Quitosano	3	1	2	5	5	5	1	3	2	2	5	5	4	4	2	4	4	1	3	4	1	3	3	1	3	2	3	3	3	3
Warm your feet plus	4	1	2	3	3	4	1	2	2	2	3	3	3	3	3	5	5	5	3	5	1	4	4	1	3	2	5	4	5	5
Biconvergence2Utilities	3	1	4	2	2	3	1	2	2	2	3	3	3	3	1	5	5	3	1		1	5	5	1	4	1	5	4	4	4
Flexicover	3	2	3	2	2	3	4	3	3	3	4	4	5	5	5	5	5	5	1		3	4	4	3	5	5	5	5	4	4.5
Atm	4	4	5	3	3	5	4	5	5	5	3	3	3	3	1	5	5	5	1		1	5	5	3	3	1	5	5	4	3

Saltquanti	4	2	5	3	3	3	4	3	2	2	3	3	5	5	5	2	2	1	3	4	3	4	4	3	5	2	5	5	5	4
Mapple	4	2	5	3	3	3	4	5	4	4	4	4	4	4	2	5	5	5	1		1	4	4	3	5	5	5	5	4	5
Bepim III	4	5	4	5	5	5	2	5	2	2	2	2	3	3	3	4	4	3	1		1	2	2	1	3	4	5	5	5	5
FogDigest	2	4	3	5	5	5	3	3	2	2	5	5	4	4	2	2	2	3	3	5	5	5	5	3	5	4	1	3	5	4.5
Glpap	5	1	4	3	3	3	1	2	2	2	5	5	3	3	2	5	5	5	3	4	1	3	3	1	3	1	1	3	4	3.5
Isomatis	4	2	3	4	4	4	4	3	4	4	4	4	4	4	4	5	5	5	3	4	1	2	2	3	3	5	5	5	5	3
DemoCrat	1	1	4	3	3	3	1	3	2	2	2	2	4	4	2	4	4	3	1		1	5	5	1	5	4	5	4	3	3
Integrated platform	3	1	4	1	1	2	1	2	2	2	3	3	3	3	3	5	5	5	1		1	4	4	1	5	4	5	4	3	3
Monicap M4X	4	1	4	3	3	3	1	2	2	2	3	3	3	3	3	5	5	5	1		1	1	1	1	4	2	5	4	5	5
HS.Helios	2	5	5	4	4	4	5	3	4	4	5	5	2	2	2	5	5	5	1		1	2	2	5	5	2	5	5	5	4.5
Multicomposite	2	2	3	3	3	3	2	3	3	3	1	1	3	3	4	4	4	1	1		3	2	3	3	4	5	3	3	5	5
V2G	3	2	3	1	1	2	3	3	3	3	3	3	4	4	4	5	5	5	1		1	2	2	3	3	2	5	5	5	5
Voiscriptum	4	1	4	3	3	3	1	2	2	2	3	3	2	2	1	5	5	5	1		1	2	2	1	3	2	5	4	3	4
Eml	4	3	3	4	4	4	3	3	4	4	4	4	5	5	5	5	5	5	1		3	2	2	3	4	1	3	3	5	4.5
Mammoassist	4	4	5	2	2	5	2	3	3	3	5	5	2	2	2	5	5	5	1		1	3	3	1	5	1	5	5	4	4
In2dig	4	4	3	5	5	5	4	3	4	4	3	3	3	3	3	5	5	5	5	4	1	3	3	3	5	5	5	5	4	4
i2S	3	1	4	2	2	3	1	1	2	2	1	1	2	2	3	5	5	5	3	3	5	2	2	1	3	1	1	2	3	3
Pams	1	1	2	1	1	3	1	1	2	2	1	1	3	3	2	4	4	3	3	5	1	3	3	1	3	4	3	3	3	3
Balestilha	1	1	4	5	5	3	1	2	2	2	4	4	4	4	4	5	5	5	3	4	1	5	5	1	5	4	5	4	4	5
Next-gen raid	1	1	4	4	4	3	1	3	2	2	3	3	3	3	2	5	5	5	5	4	1	5	5	1	5	4	5	4	3	3
Winegrid	4	1	4	3	3	3	1	1	2	2	4	4	3	3	3	5	5	5	3	4	3	5	5	1	3	1	5	4	4	4.5
Gnesis	2	4	5	5	5	5	5	5	3	3	5	5	3	3	2	4	4	1	3	5	5	4	4	5	5	5	5	5	5	5
NPS_Hi_Tech	3	1	3	1	1	3	1	2	2	2	3	3	3	3	3	4	4	3	3	4	1	2	2	1	3	1	5	4	4	5
Veeco2Market	5	1	2	4	4	5	1	2	2	2	3	3	3	3	4	4	4	3	3	4	3	4	4	1	5	1	1	2	4	5
HS.Register	4	5	5	3	3	3	5	5	5	5	5	5	2	2	2	5	5	5	3	3	5	2	2	5	3	2	5	5	5	5
Depcat	5	5	5	5	5	4	5	5	5	5	3	3	5	5	5	2	2	1	3	4	5	4	4	5	5	5	5	5	5	5
See-Q	1	1	2	4	4	5	1	2	2	2	3	3	3	3	2	5	5	5	3	5	5	5	5	1	4	4	5	4	3	3
Pro-UPMS	3	1	4	1	1	2	1	1	2	2	1	1	3	3	4	5	5	5	3	4	5	3	3	1	4	2	5	4	5	5
BioCombus III	3	2	3	5	5	5	3	5	5	5	1	1	5	5	2	5	5	5	5	4	3	3	3	3	5	2	3	3	3	3
Demo c parts	4	3	3	5	5	5	4	5	5	5	3	3	4	4	3	3	3	3	3	5	1	5	5	3	5	5	5	5	5	5
Corewall	4	1	4	3	3	5	1	5	2	2	2	2	4	4	4	4	4	3	1		1	1	1	1	3	2	1	2	4	4.5
Super Volume Comp	4	1	4	3	3	4	1	2	2	2	3	3	4	4	4	5	5	5	1		1	3	3	1	4	4	1	2	4	4.5
Insight	4	1	4	4	4	3	1	3	2	2	3	3	3	3	2	5	5	5	1		5	2	2	1	5	2	3	3	5	5
Preslabtec	5	5	3	5	5	5	3	5	4	4	5	5	4	4	4	4	4	3	1		1	5	5	3	4	2	5	5	3	3
SBIDemo	3	1	2	5	5	5	1	3	2	2	3	3	3	3	2	5	5	5	1		1	5	5	1	3	2	5	4	3	3

<u>Note:</u> *Co-promotion* Demonstrator projects are in **dark green** and the *individual* ones in **light green**.

Appendix V – *Ex-ante* assessment: *final scoring* obtained by the Demonstrators through the *New referential* (Part II)

Demonstrator projects	***Coherence and rationality***	***Intensity and adequacy of R&D inputs***	***Degree of novelty of innovation activities***	***Scope of R&D outputs and diffusion***	***Impact on business competitiveness and economy***	***Final scoring***
	$\mathbf{i} = 0.1i_1 + 0.2i_2 + 0.1i_3 + 0.2i_4 + 0.2i_5 + 0.2i_6$	$\mathbf{ii} = 0.2ii_1 + 0.2ii_2 + 0.1ii_3 + 0.1ii_4 + 0.2ii_5 + 0.2ii_6$	$\mathbf{iii} = 0.1iii_1 + 0.1iii_2 + 0.2iii_3 + 0.1iii_4 + 0.3iii_5 + 0.2iii_6$	$\mathbf{iv} = 0.1iv_1 + 0.1iv_2 + 0.1iv_3 + 0.2iv_4 + 0.2iv_5 + 0.2iv_6$	$\mathbf{v} = 0.2v_1 + 0.1v_2 + 0.1v_3 + 0.2v_4 + 0.2v_5 + 0.2v_6$	**Project merit** $= 0.3i + 0.2ii + 0.1iii + 0.1iv + 0.3v$
Coopweld 5	**5.0**	**4.8**	**5.0**	**3.5**	**4.8**	**4.75**
WGR	**3.7**	**3.2**	**4.4**	**3.6**	**4.4**	**3.87**
Breath2Seat	**3.2**	**4.0**	**3.6**	**2.3**	**3.7**	**3.46**
Prodiam	**3.4**	**3.8**	**2.9**	**3.1**	**4.3**	**3.67**
CerWave	**3.6**	**4.8**	**4.6**	**3.7**	**3.6**	**3.95**
Lamitech	**2.1**	**2.6**	**2.2**	**0.9**	**3.8**	**2.60**
AIMS2	**3.6**	**3.4**	**5.0**	**3.3**	**4.3**	**3.88**
Revifeel Plus	**3.4**	**3.0**	**3.0**	**3.7**	**3.7**	**3.40**
Shopview2market	**2.6**	**3.0**	**4.2**	**3.2**	**4.0**	**3.32**
Peddir	**3.3**	**4.6**	**4.2**	**3.7**	**4.6**	**4.08**
HBios Demo	**4.1**	**2.2**	**2.4**	**1.9**	**3.1**	**3.03**
Safe	**4.0**	**3.0**	**4.2**	**1.3**	**4.5**	**3.70**
Validata	**3.9**	**3.4**	**3.6**	**1.7**	**4.4**	**3.70**
Flexstone	**3.9**	**3.0**	**4.2**	**3.7**	**4.9**	**4.03**
Algaecoat	**3.4**	**4.0**	**2.4**	**3.3**	**4.9**	**3.86**
NedDisplay	**3.7**	**3.2**	**4.4**	**4.2**	**4.4**	**3.93**
Asic Tofpet 2	**3.0**	**3.2**	**4.2**	**2.5**	**3.9**	**3.38**
Cork.a.tex-yarm	**3.9**	**3.4**	**3.7**	**3.8**	**5.0**	**4.10**
Sidenav	**4.0**	**4.4**	**4.2**	**2.5**	**3.9**	**3.92**
DNArterial Decoder	**3.1**	**4.2**	**4.2**	**3.4**	**4.1**	**3.76**
DEMO@Polyfenton	**4.1**	**3.8**	**3.0**	**3.7**	**4.4**	**3.98**
MediTube	**3.2**	**1.8**	**3.2**	**3.6**	**3.6**	**3.08**
Celsmart Sense	**3.2**	**4.6**	**3.4**	**4.4**	**4.9**	**4.13**
DemoExp	**3.1**	**2.8**	**3.6**	**3.6**	**4.3**	**3.50**
CallScriber	**3.6**	**1.6**	**4.0**	**1.7**	**4.1**	**3.20**
Sei	**2.8**	**1.8**	**4.4**	**2.1**	**3.8**	**2.99**
Ship	**3.3**	**3.2**	**3.4**	**3.1**	**4.7**	**3.69**
LedinTex	**2.9**	**3.4**	**5.0**	**3.8**	**5.0**	**3.93**
DEM@Biofumados	**2.9**	**3.2**	**2.6**	**2.7**	**4.3**	**3.33**
Netefficity	**3.3**	**2.4**	**4.0**	**4.3**	**3.9**	**3.47**
Magline	**4.2**	**2.8**	**3.4**	**3.6**	**3.9**	**3.69**
P4sert	**2.3**	**2.6**	**3.8**	**2.7**	**3.7**	**2.97**
Walkon Demo	**3.5**	**3.0**	**3.2**	**2.1**	**4.2**	**3.44**
Fermalg	**3.1**	**2.6**	**2.2**	**2.5**	**4.3**	**3.21**
Quitosano	**3.7**	**3.2**	**2.8**	**2.3**	**2.9**	**3.13**

Warm your feet plus	**2.8**	**2.2**	**4.2**	**2.8**	**4.1**	**3.21**
Biconvergence2Utilities	**2.3**	**2.2**	**3.4**	**3.1**	**3.8**	**2.92**
Flexicover	**2.4**	**3.6**	**5.0**	**2.9**	**4.7**	**3.64**
Atm	**3.9**	**4.0**	**3.8**	**3.1**	**4.0**	**3.86**
Saltquanti	**3.1**	**3.0**	**3.0**	**3.5**	**4.5**	**3.53**
Mapple	**3.1**	**4.2**	**4.2**	**2.7**	**4.8**	**3.90**
Bepim III	**4.8**	**2.6**	**3.4**	**1.3**	**4.5**	**3.78**
FogDigest	**4.3**	**3.6**	**2.6**	**4.2**	**4.0**	**3.89**
Glpap	**2.9**	**3.0**	**4.0**	**2.3**	**2.9**	**2.97**
Isomatis	**3.5**	**3.8**	**4.6**	**2.5**	**4.2**	**3.78**
DemoCrat	**2.5**	**2.0**	**3.4**	**3.1**	**3.9**	**2.97**
Integrated platform	**1.7**	**2.2**	**4.2**	**2.1**	**3.9**	**2.75**
Monicap M4X	**2.8**	**2.2**	**4.2**	**0.9**	**4.3**	**3.08**
HS.Helios	**4.1**	**4.4**	**3.8**	**2.5**	**4.6**	**4.12**
Multicomposite	**2.7**	**2.0**	**3.2**	**1.5**	**4.2**	**2.94**
V2G	**1.8**	**3.0**	**4.6**	**1.3**	**4.3**	**3.02**
Voiscriptum	**2.8**	**2.2**	**3.6**	**1.3**	**3.5**	**2.82**
Eml	**3.7**	**3.6**	**5.0**	**1.5**	**3.7**	**3.59**
Mammoassist	**3.5**	**3.6**	**3.8**	**1.7**	**4.4**	**3.64**
In2dig	**4.5**	**3.4**	**4.2**	**3.1**	**4.6**	**4.14**
i2S	**2.3**	**1.2**	**4.0**	**2.2**	**2.4**	**2.27**
Pams	**1.5**	**1.2**	**3.2**	**2.4**	**3.1**	**2.18**
Balestilha	**3.3**	**2.6**	**3.6**	**3.1**	**4.5**	**3.53**
Next-gen raid	**2.9**	**2.4**	**4.0**	**4.5**	**3.9**	**3.37**
Winegrid	**2.8**	**2.4**	**4.2**	**4.5**	**3.7**	**3.30**
Gnesis	**4.5**	**4.6**	**2.8**	**4.4**	**5.0**	**4.49**
NPS_Hi_Tech	**1.8**	**2.2**	**3.4**	**1.9**	**3.8**	**2.65**
Veeco2Market	**3.5**	**2.2**	**3.6**	**2.9**	**3.4**	**3.16**
HS.Register	**3.7**	**5.0**	**3.8**	**3.4**	**4.3**	**4.12**
Depcat	**4.8**	**4.2**	**3.0**	**4.3**	**5.0**	**4.01**
See-Q	**3.1**	**2.2**	**4.0**	**3.6**	**3.7**	**3.24**
Pro-UPMS	**1.7**	**1.2**	**4.4**	**2.7**	**4.3**	**2.75**
BioCombus III	**4.0**	**3.0**	**4.4**	**3.3**	**3.3**	**3.56**
Demo c parts	**4.3**	**4.0**	**3.2**	**3.8**	**5.0**	**4.29**
Corewall	**2.8**	**2.4**	**3.8**	**0.9**	**2.8**	**2.63**
Super Volume Comp	**3.0**	**2.2**	**4.6**	**2.7**	**3.4**	**2.99**
Insight	**3.2**	**2.4**	**4.0**	**1.7**	**4.1**	**3.24**
Preslabtec	**4.8**	**4.4**	**3.8**	**3.1**	**3.7**	**4.12**
SBIDemo	**4.0**	**2.4**	**4.0**	**2.5**	**3.3**	**3.32**

Note: The Demonstrator Project with the **highest final scoring** in the applications' selection and assessment stage is represented by .
The Demonstrator Project with the **lowest final scoring** in the applications' selection and assessment stage is represented by .

Appendix VI– A*d-interim* and *ex-post* assessment*: scorings* achieved by the Demonstrators in accordance with *Innovation Radar*

Demonstrator projects	***Innovation potential indicator***				***Innovation capacity indicator***		
	Innovation readiness	***Innovation management***	***Market potential***	***Scoring IPI***	***Innovator's ability***	***Innovator's environment***	***Scoring ICI***
Coopweld 5	**4.9**	**3.8**	**3.4**	**4.0**	**4.1**	**4.5**	**4.3**
WGR	**4.5**	**3.0**	**3.2**	**3.6**	**2.1**	**3.5**	**2.8**
Breath2Seat	**4.0**	**2.5**	**3.2**	**3.2**	**2.2**	**1.8**	**2.0**
Prodiam	**3.8**	**2.3**	**2.3**	**2.8**	**2.1**	**2.8**	**2.5**
CerWave	**3.7**	**1.8**	**2.7**	**2.7**	**3.5**	**2.3**	**2.9**
Lamitech	**4.2**	**1.8**	**1.9**	**2.6**	**1.3**	**0.8**	**1.1**
AIMS2	**4.0**	**2.0**	**2.2**	**2.7**	**2.7**	**2.0**	**2.4**
Revifeel Plus	**3.9**	**1.3**	**2.3**	**2.5**	**1.3**	**2.8**	**2.1**
Shopview2market	**4.5**	**2.8**	**3.0**	**3.4**	**1.8**	**1.0**	**1.4**
Peddir	**3.5**	**2.5**	**2.7**	**2.9**	**1.9**	**2.8**	**2.4**
HBios Demo	**3.8**	**2.3**	**2.0**	**2.7**	**1.3**	**2.8**	**2.1**
Safe	**3.4**	**2.3**	**2.4**	**2.7**	**2.5**	**2.8**	**2.7**
Validata	**3.5**	**2.3**	**1.8**	**2.5**	**2.0**	**2.8**	**2.4**
Flexstone	**4.3**	**2.3**	**3.2**	**3.2**	**3.4**	**2.8**	**3.1**
Algaecoat	**3.7**	**1.5**	**3.0**	**2.7**	**1.8**	**3.3**	**2.6**
NedDisplay	**2.7**	**1.0**	**2.9**	**2.2**	**1.5**	**1.0**	**1.3**
Asic Tofpet 2	**3.3**	**2.3**	**2.2**	**2.6**	**1.7**	**2.8**	**2.2**
Cork.a.tex-yarm	**4.8**	**2.5**	**3.4**	**3.6**	**3.3**	**5.0**	**4.2**
Sidenav	**1.7**	**2.3**	**2.3**	**2.1**	**1.5**	**1.0**	**1.2**
DNArterial Decoder	**4.2**	**2.0**	**2.8**	**3.0**	**2.4**	**3.5**	**3.0**
DEMO@Polyfenton	**3.7**	**2.3**	**2.3**	**2.7**	**2.9**	**5.0**	**4.0**
MediTube	**2.7**	**1.3**	**2.5**	**2.2**	**1.6**	**2.3**	**2.5**
Celsmart Sense	**4.5**	**3.0**	**2.8**	**3.4**	**2.8**	**3.5**	**3.2**
DemoExp	**3.0**	**0.8**	**2.0**	**1.9**	**2.5**	**2.8**	**2.7**
CallScriber	**3.2**	**2.5**	**3.3**	**3.0**	**1.7**	**2.3**	**2.0**
Sei	**3.2**	**2.0**	**2.8**	**2.7**	**1.8**	**2.3**	**2.1**
Ship	**3.8**	**1.8**	**3.0**	**2.2**	**2.1**	**2.3**	**2.2**
LedinTex	**3.9**	**3.0**	**3.7**	**3.4**	**2.9**	**3.5**	**3.2**
DEM@Biofumados	**3.8**	**2.5**	**2.5**	**1.9**	**1.8**	**2.3**	**2.1**
Netefficity	**3.9**	**1.8**	**3.3**	**3.0**	**2.1**	**2.8**	**2.5**
Magline	**4.7**	**3.5**	**3.0**	**2.7**	**2.9**	**4.5**	**3.7**
P4sert	**3.5**	**1.5**	**2.7**	**2.9**	**1.7**	**0.5**	**1.1**
Walkon Demo	**3.9**	**3.3**	**3.3**	**3.5**	**2.1**	**2.8**	**2.5**
Fermalg	**3.7**	**2.5**	**2.3**	**2.8**	**1.7**	**3.5**	**2.6**
Quitosano	**3.4**	**2.0**	**2.8**	**2.7**	**1.4**	**2.8**	**2.1**
Warm your feet plus	**3.5**	**1.8**	**2.5**	**2.6**	**1.5**	**3.5**	**2.5**
Biconvergence2Utilities	**2.2**	**1.8**	**1.8**	**1.9**	**1.2**	**2.0**	**1.6**

Flexicover	**3.4**	**3.0**	**3.2**	**3.2**	**2.3**	**2.8**	**2.6**
Atm	**4.0**	**1.8**	**1.9**	**3.0**	**1.5**	**1.0**	**1.3**
Saltquanti	**2.8**	**2.8**	**3.3**	**2.6**	**3.0**	**4.5**	**3.8**
Mapple	**3.5**	**1.5**	**3.3**	**2.8**	**3.4**	**3.0**	**3.2**
Bepim III	**2.7**	**2.8**	**2.4**	**2.6**	**3.2**	**4.5**	**3.9**
FogDigest	**2.3**	**1.5**	**2.8**	**2.2**	**1.8**	**2.3**	**2.1**
Glpap	**1.7**	**1.3**	**3.0**	**2.0**	**1.6**	**2.3**	**1.9**
Isomatis	**3.2**	**3.3**	**3.2**	**3.2**	**1.8**	**3.0**	**2.4**
DemoCrat	**2.0**	**1.8**	**2.3**	**2.0**	**1.3**	**1.3**	**1.3**
Integrated platform	**1.9**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**
Monicap M4X	**2.3**	**2.8**	**2.2**	**2.4**	**1.6**	**2.3**	**2.0**
HS.Helios	**4.8**	**4.3**	**3.0**	**4.0**	**3.0**	**3.5**	**3.3**
Multicomposite	**3.0**	**3.0**	**2.5**	**2.9**	**1.6**	**2.3**	**2.0**
V2G	**3.2**	**2.3**	**2.5**	**2.7**	**1.8**	**3.0**	**2.4**
Voiscriptum	**2.4**	**2.3**	**1.7**	**2.1**	**1.2**	**1.8**	**1.5**
Eml	**3.3**	**3.5**	**3.0**	**3.3**	**2.1**	**2.3**	**2.2**
Mammoassist	**3.2**	**2.8**	**2.0**	**2.7**	**2.2**	**3.5**	**2.9**
In2dig	**4.8**	**4.5**	**3.5**	**4.3**	**4.0**	**4.0**	**4.0**
i2S	**1.7**	**2.0**	**2.2**	**2.0**	**1.0**	**0.8**	**0.9**
Pams	**1.4**	**1.5**	**2.0**	**1.7**	**1.1**	**1.3**	**1.2**
Balestilha	**2.4**	**2.8**	**2.8**	**2.7**	**1.7**	**2.8**	**2.3**
Next-gen raid	**2.7**	**1.8**	**2.3**	**2.2**	**2.1**	**1.8**	**2.0**
Winegrid	**2.5**	**2.5**	**2.5**	**2.5**	**1.6**	**2.8**	**2.2**
Gnesis	**4.5**	**3.5**	**3.7**	**3.9**	**4.1**	**5.0**	**4.6**
NPS_Hi_Tech	**2.2**	**2.0**	**2.0**	**2.1**	**1.3**	**0.8**	**1.1**
Veeco2Market	**2.7**	**2.0**	**2.7**	**2.5**	**1.9**	**2.3**	**2.1**
HS.Register	**4.5**	**3.3**	**3.5**	**3.8**	**4.0**	**3.5**	**3.8**
Depcat	**3.7**	**4.0**	**2.8**	**3.5**	**3.6**	**3.0**	**3.3**
See-Q	**2.5**	**2.0**	**3.3**	**2.5**	**1.8**	**2.3**	**2.1**
Pro-UPMS	**2.3**	**2.0**	**3.3**	**2.5**	**1.4**	**1.3**	**1.4**
BioCombus III	**3.0**	**2.8**	**3.8**	**3.2**	**3.1**	**2.3**	**2.7**
Demo c parts	**5.0**	**4.8**	**4.2**	**4.7**	**4.2**	**3.5**	**3.9**
Corewall	**2.7**	**3.0**	**2.5**	**2.8**	**2.1**	**2.3**	**2.2**
Super Volume Comp	**2.5**	**2.3**	**2.7**	**2.5**	**1.9**	**2.3**	**2.1**
Insight	**2.0**	**2.5**	**3.0**	**2.5**	**2.4**	**2.3**	**2.4**
Preslabtech	**3.9**	**4.3**	**2.9**	**3.7**	**4.0**	**5.0**	**4.5**
SBIDemo	**2.8**	**2.5**	**2.3**	**2.5**	**1.8**	**3.0**	**2.4**

Note: *Co-promotion* Demonstrator projects are in **dark green** and the *individual* ones in **light green**.

Appendix VII – *Ex-ante* assessment: statistical analysis of results

VII.I – Internal consistency analysis for the creation of *analysis dimensions*

Cronbach's α is a measure of internal consistency, which is used to ascertain whether a set of items, correlated with one another, may be aggregated in order to create a new variable. Each one of the *five dimensions of analysis* was thereby created.

Aggregation of selection criteria	*Measure of internal consistency*	*Dimension*
Type of leading company Number of co-promoters Sector of activity Work plan S&T methodology Investment plan	*Cronbach's α*= 0.779 (Good)	*Coherence and rationality*
Parties involved Team's expertise Team's adequacy Need to subcontract activities Reinforcement of R&D capacity Engagement of PhD holders	*Cronbach's α* = 0.751 (Good)	*Intensity and adequacy of R&D inputs*
Type of innovation Grade of innovation Nature of innovation Technological field R&D technological intensity Degree of technological complexity	*Cronbach's α* = 0.831 (Very good)	*Degree of novelty of innovation activities*
Intellectual property registration Type of protection Positive externalities Effects of dissemination and promotion Economic valorization of results Technology transfer intensity	*Cronbach's α* = 0.793 (Good)	*Scope of innovation outputs and diffusion*
Business strategy Propensity for international markets Contribution to national economy Post-project investment on R&D Contribution to National Smart Specialization Strategy (ENEI) Regional and sectorial convergence	*Cronbach's α*= 0.761 (Good)	*Impact on business competitiveness and economy*

Design based on SPSS' *reliability analysis outputs* for the aggregation of the *five sets* of selection criteria.

VII.II – Variance analysis (ANOVA) – *Coherence and rationality*

Key-question: Does project typology actually influence performance in the *Coherence and Rationality* dimension? Do *co-promotion Demonstrators* have, on average, a better *ex-ante* assessment, on a technical and monetary level?

Project typology	Individual Demonstrator				Co-promotion Demonstrator			
	N	% Total	$\bar{\iota}$	Std. Deviation	N	% Total	$\bar{\iota}$	Std. Deviation
Type of leading company								
Micro-enterprise	6	18.8%	3.4	0.4	5	11.9%	4.5	0.6
Small-scale enterprise	11	34.4%	3.1	0.4	16	38.1%	3.6	0.6
Medium-scale enterprise	8	25.0%	2.6	0.9	11	26.2%	3.3	0.7
Large-scale enterprise	7	21.9%	2.7	0.7	10	23.8%	3.6	0.7
Number of co-promoters								
One	32	100.0%	2.9	0.7	-	-	-	-
Two	-	-	-	-	20	47.6%	3.2	0.6
Three	-	-	-	-	8	19.0%	3.7	0.7
Four or more	-	-	-	-	14	33.3%	4.2	0.5
Sector of activity								
Industry	12	37.5%	3.0	0.8	24	57.1%	3.5	0.7
Services	20	62.5%	2.9	0.6	18	42.9%	3.7	0.7
Work plan								
Weak/Non-existing information	-	-	-	-	-	-	-	-
With some deficiencies	5	15.6%	2.0	0.4	4	9.5%	2.3	0.3
Averagely devised	10	31.3%	2.7	0.5	11	26.2%	3.3	0.3
Well-devised	6	18.8%	3.1	0.4	14	33.3%	3.5	0.4
Very-well devised	11	34.4%	3.5	0.4	13	31.0%	4.4	0.4
S&T methodology								
Weak description	1	3.1%	1.7	0.0	-	-	-	-
Defective description	3	9.4%	1.7	0.2	2	4.8%	2.7	1.2
Average description	10	31.3%	2.7	0.3	12	28.6%	3.0	0.4
Good description	13	40.6%	3.2	0.4	16	38.1%	3.6	0.3
Excellent description	5	15.6%	3.8	0.2	12	28.6%	4.5	0.3
Investment plan								
Insufficient resources/No information	-	-	-	-	-	-	-	-
Uneven resources	2	6.3%	1.7	0.0	2	4.8%	2.2	0.6
Reasonable budget	15	46.9%	2.6	0.5	13	31.0%	3.1	0.4
Sustained budget	5	15.6%	3.3	0.5	17	40.5%	3.8	0.4
Balanced and rightly sustained budget	10	31.3%	3.5	0.4	10	23.8%	4.4	0.5

Three basic assumptions:

- *Independent samples* (*i.e.,* project typologies):

Individual and co-promotion Demonstrator projects are not connected among themselves, or in other words, the *scores* of *co-promotion projects' coherence and rationality* are **independent** from the *scores* of the *individual projects' dimension i*. The assumption of independent samples is thus **ensured**.[71]

[71] Put differently, considering that the *co-promotion projects* are not the same as the *individual projects*, the *samples* are necessarily *independent*.

***- Sampling of groups that are normally distributed*:**

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether *dimension i* **follows a normal distribution** in the *co-promotion* projects' group, as well as in the *individual* projects' group, the *Central Limit Theorem* is applied. It should be pointed out that there is a considerable sample of *co-promotion projects* ($n_{CP} = 42 > 30$) and that the execution of the Theorem proves this assumption. On the other hand, regarding *individual projects*, even though their sample is thinner ($n_{IP} = 32 > 30$), it was possible to determine, through the application of the *Central Limit Theorem*, that the violation of this assumption does not have serious consequences.

***- Homogeneity of variance*:**

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the *Levene's test* is conducted, considering the following hypotheses:

H_0: variance in the *coherence and rationality* dimension is equal in the two project typologies ($\delta_{Dimension\ i\ CP}{}^2 = \delta_{Dimension\ i\ IP}{}^2$).

H_a: variance in the *coherence and rationality* dimension is different in the two project typologies ($\delta_{Dimension\ i\ CP}{}^2 \neq \delta_{Dimension\ i\ IP}{}^2$).

Test of Homogeneity of Variances

Coherence and rationality

Levene Statistic	df1	df2	Sig.
,261	1	72	,611

Levene $_{(1;72)} = 0.261$; *p-value* $= 0.611 > \alpha = 0.05$[72], therefore the null hypothesis (H_0) of the equality of variances is not rejected. In other words, it is assumed they are equal. In this regard, the dispersion of the *coherence and rationality* dimension, measured by the variance, is not influenced by the two project typologies. ***Assumption confirmed***.

The *one-way ANOVA*[73] can thus be conducted. The guiding hypotheses of the *one-way ANOVA* test are:

H_0: on average, the assessment on the *coherence and rationality* dimension is equal in *co-promotion* and *individual* projects ($\mu_{Dimension\ i\ CP} = \mu_{Dimension\ i\ IP} \Leftrightarrow \mu_{Dimension\ i\ CP} - \mu_{Dimension\ i\ IP} = 0$).

H_a: on average, the assessment on the *coherence and rationality* dimension is different in the *co-promotion* and *individual* projects ($\mu_{Dimension\ i\ CP} \neq \mu_{Dimension\ i\ IP} \Leftrightarrow \mu_{Dimension\ i\ CP} - \mu_{Dimension\ i\ IP} \neq 0$).

[72] In *Snedecor*'s F distribution tests, there are usually two degrees of freedom (*df*). The first one corresponds to the number of compared groups, *i.e.,* $k - 1 = 2 - 1 = 1$, and the second one to the dimension of the sample under analysis, i.e., $n - k = 74 - 2 = 72$. Therefore *df1* = 1 e *df2* = 72.
[73] Provided the assumptions were not confirmed, namely the normality one, the *Kruskal-Wallis H* non-parametric test would be conducted as an alternative.

ANOVA

Coherence and rationality

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8,570	1	8,570	17,369	,000
Within Groups	35,524	72	,493		
Total	44,094	73			

Since *p-value* = 0.00 < α = 0.05, then H_0 is rejected. The *post-hoc*[74] tests show **statistical significance** to support (and argue) that, on average, the assessment in the *coherence and rationality* dimension is **different between the two typologies** ($F_{(1;72)}$ = 17.369; *p-value* = 0.00).

Robust Tests of Equality of Means

Coherence and rationality

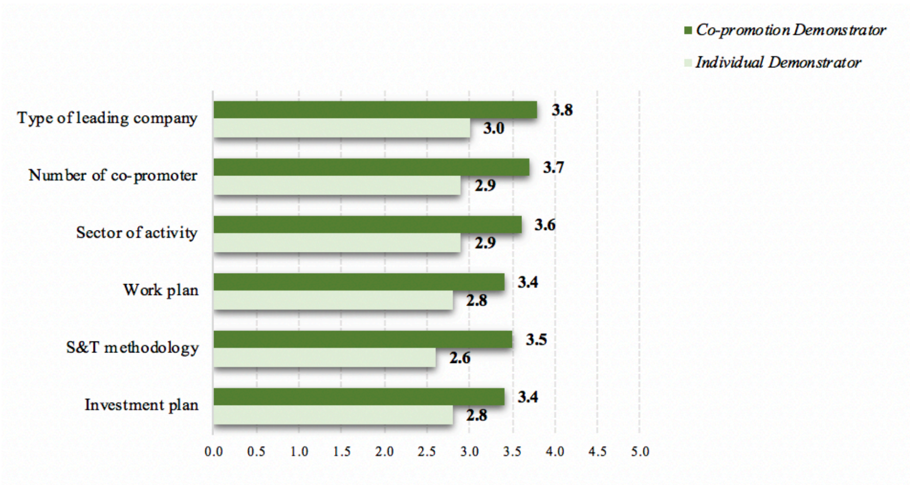
	Statistic[a]	df1	df2	Sig.
Welch	17,651	1	68,734	,000
Brown-Forsythe	17,651	1	68,734	,000

a. Asymptotically F distributed.

		Coherence and rationality				
		Mean	Standard Deviation	Maximum	Median	Minimum
Project typology	Co-promotion	3,61	,72	5,00	3,55	1,80
	Individual	2,93	,68	4,00	2,95	1,50

Directional Measures

			Value
Nominal by Interval	Eta	Coherence and rationality Dependent	,441
		Project typology Dependent	,679



[74] The *post-hoc* tests are conducted when the *one-way ANOVA* test for equality of means (*Welch* or *Brown-Forsythe*) suggests that there is at least one group with the mean different from the others. In this case, the *post-hoc* tests identify the sets of population groups which differ from one another, on average.

VII.III –Variance analysis (ANOVA) – *Intensity and Adequacy of R&D inputs*

Key-question: Does project typology actually influence the performance in the *Intensity and Adequacy of R&D inputs* dimension? Do *co-promotion projects* have, on average, a better *ex-ante* assessment regarding R&D and innovation inputs?

Project typology	Individual Demonstrator				Co-promotion Demonstrator			
	N	% Total	$\overline{u}$	Std. Deviation	N	% Total	$\overline{u}$	Std. Deviation
Parties involved								
Companies	32	100.0%	2.4	0.6	4	9.5%	2.8	0.6
Companies and universities/polytechnic institutes	-	-	-	-	12	28.6%	3.5	0.8
Companies and R&D centres	-	-	-	-	20	47.6%	3.7	0.7
Companies, universities/polytechnic institutes and R&D centres	-	-	-	-	6	14.3%	4.2	0.7
Team's expertise								
Weak	5	15.6%	1.7	0.7	-	-	-	-
Average	20	62.5%	2.4	0.4	24	57.1%	3.3	0.6
Strong	7	21.9%	2.9	0.4	18	42.9%	4.1	0.7
Team's adequacy								
Null	-	-	-	-	-	-	-	-
Weak	25	78.1%	2.2	0.6	2	4.8%	2.8	0.3
Average	5	15.6%	2.6	0.4	23	54.8%	3.3	0.6
Strong	2	6.3%	3.2	0.3	17	40.4%	4.1	0.7
Need to subcontract activities								
No	3	9.4%	3.2	0.2	20	47.7%	3.9	0.6
Yes, in accessory activities	2	6.3%	2.9	0.4	14	33.3%	3.6	0.8
Yes, in core activities	27	84.4%	2.2	0.5	8	19.0%	2.9	0.6
Reinforcement of R&D capacity regarding new appointments								
Low (C Index ≤ 5)	10	31.3%	1.9	0.7	10	23.8%	3.1	0.6
Average (5 <C Index ≤ 20)	4	12.5%	2.5	0.4	7	16.7%	2.9	0.7
High (C Index > 20)	18	56.3%	2.6	0.4	25	59.5%	4.0	0.6
Engagement of PhD holders								
Low (D Index ≤ 5)	13	40.6%	1.9	0.5	11	26.2%	3.0	0.6
Average (5 <D Index ≥ 20)	12	37.5%	2.6	0.5	14	33.3%	3.3	0.5
High (D Index > 20)	7	21.9%	2.8	0.4	17	40.5%	4.3	0.4

Three basic assumptions:

- *Independent samples* (*i.e.,* project typologies):

Individual and co-promotion Demonstrator projects are not connected among themselves, or in other words, the scores of *co-promotion projects' intensity and* *adequacy of R&D inputs* are **independent** from the scores of the *individual projects' dimension ii*. The assumption of independent samples is thus **ensured**.[75]

***- Sampling of groups that are normally distributed*:**

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether *dimension ii* follows a normal distribution in the *co-promotion* projects' group, as well as in the *individual* projects' group, the ***Central Limit Theorem*** is applied. It should be pointed out that there is a considerable sample of *co-promotion* projects ($n_{CP} = 42 > 30$) and that the execution of the Theorem proves this assumption. On the other hand, regarding individual projects, even though their sample is thinner ($n_{IP} = 32 > 30$), it was possible to determine, through the application of the ***Central Limit Theorem***, that the violation of this assumption does not have serious consequences.

***- Homogeneity of variance*:**

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the ***Levene's test*** is conducted, considering the following hypotheses:

H_0: variance in the *intensity and adequacy of R&D inputs* dimension is equal in the two project typologies ($\delta_{Dimension\ ii\ CP}{}^2 = \delta_{Dimension\ ii\ IP}{}^2$).

H_a: variance in the *intensity and adequacy* dimension is different in the two project typologies ($\delta_{Dimension\ ii\ CP}{}^2 \neq \delta_{Dimension\ ii\ IP}{}^2$).

Test of Homogeneity of Variances

Intensity and adequacy of R&D inputs

Levene Statistic	df1	df2	Sig.
3,546	1	72	,064

Levene $_{(1;72)} = 3.546$; *p-value* $= 0.064 > \alpha = 0.05$[76], therefore the null hypothesis (H_0) of the equality of variances is not rejected. In other words, it is assumed they are equal. In this regard, the dispersion of the *intensity and adequacy of R&D inputs* dimension, measured by the variance, is not influenced by the two project typologies. ***Assumption confirmed***.

The ***one-way ANOVA***[77] can thus be conducted.

The guiding hypotheses of the *one-way ANOVA* test are:

[75] Put differently, considering that the co-promotion projects are not the same as the individual projects, the *samples* are necessarily *independent*.
[76] In *Snedecor*'s F distribution tests, there are usually two degrees of freedom (*df*). The first one corresponds to the number of compared groups, *i.e.,k* – 1 = 2 – 1 = 1, and the second one to the dimension of the sample under analysis, i.e., n– *k* = 74 – 2 = 72. Therefore *df1* = 1 e *df2* = 72.
[77] Provided the assumptions were not confirmed, namely the normality one, the *Kruskal-Wallis H* non-parametric test would be conducted as an alternative.

H_0: on average, the assessment on the *intensity and adequacy of R&D inputs* dimension is equal in the *co-promotion* and *individual* projects ($\mu_{Dimension\ ii\ CP} = \mu_{Dimension\ ii\ IP} \Leftrightarrow \mu_{Dimension\ ii\ CP} - \mu_{Dimension\ ii\ IP} = 0$).

H_a: on average, the assessment on the *intensity and adequacy of R&D inputs* dimension is different in the *co-promotion* and *individual* projects ($\mu_{Dimension\ ii\ CP} \neq \mu_{Dimension\ ii\ IP} \Leftrightarrow \mu_{Dimension\ ii\ CP} - \mu_{Dimension\ ii\ IP} \neq 0$).

ANOVA

Intensity and adequacy of R&D inputs

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	28,527	1	28,527	60,598	,000
Within Groups	33,895	72	,471		
Total	62,422	73			

Since *p-value*= 0.00 < α = 0.05, then H_0 is rejected. The *post-hoc*[78] tests show **statistical significance** to support (and argue) that, on average, the assessment in the *intensity and adequacy of R&D inputs* dimension is **different between the two typologies** ($F_{(1;72)} = 60.598$; *p-value* = 0.000).

Robust Tests of Equality of Means

Intensity and adequacy of R&D inputs

	Statistic[a]	df1	df2	Sig.
Welch	64,756	1	71,942	,000
Brown-Forsythe	64,756	1	71,942	,000

a. Asymptotically F distributed.

		Intensity and adequacy of R&D inputs				
		Mean	Standard Deviation	Minimum	Median	Maximum
Project typology	Co-promotion	3,61	,75	2,00	3,60	5,00
	Individual	2,36	,59	1,20	2,30	3,40

Directional Measures

			Value
Nominal by Interval	Eta	Intensity and adequacy of R&D inputs Dependent	,676
		Project typology Dependent	,762

[78] The *post-hoc* tests are conducted when the *one-way ANOVA* test for equality of means (*Welch* or *Brown-Forsythe*) suggests that there is at least one group with the mean different from the others. In this case, the *post-hoc* tests identify the sets of population groups which differ from one another, on average.

VII.IV – Variance analysis (ANOVA) – *Degree of novelty of innovation activities*

Key-question: Does project typology actually influence the performance in the *Degree of novelty of innovation activities* dimension? Do *co-promotion projects* have, on average, a better *ex-ante* assessment regarding technological solution?

Project typology	Individual Demonstrator				Co-promotion Demonstrator			
	N	% Total	$\overline{\iota\iota\iota}$	Std. Deviation	N	% Total	$\overline{\iota\iota\iota}$	Std. Deviation
Type of innovation								
Product innovation	8	25.0%	4.0	0.5	17	40.5%	4.0	0.9
Process innovation	15	46.9%	3.6	0.7	19	45.2%	3.6	0.7
Organizational innovation (technology-based)	9	28.1%	3.8	0.2	6	14.3%	3.7	0.4
Class of innovation								
Non-existant	-	-	-	-	-	-	-	-
Incremental	19	59.4%	3.7	0.6	17	40.5%	3.6	0.6
Radical	13	40.6%	3.8	0.6	25	59.5%	3.9	0.8
Nature of innovation								
Changes in the organization structure	3	9.4%	3.5	0.0	1	2.4%	3.8	0.0
Introduction of new sources of *input* supply	13	40.6%	3.6	0.7	11	26.2%	3.7	0.7
Opening of a new market	2	6.3%	4.2	0.0	1	2.4%	2.8	0.0
Improvement of an existing production method	8	25.0%	3.9	0.5	6	14.3%	3.7	0.5
Qualitative improvement of an existing product	6	18.8%	3.9	0.8	6	14.3%	3.3	0.6
Introduction of a new production method	-	-	-	-	6	14.3%	3.7	0.8
Introduction of a new product	-	-	-	-	11	26.2%	4.3	0.9
Technological field								
Biotechnology and agro-sciences	4	12.5%	2.9	0.9	6	14.3%	2.7	0.4
Materials and construction	2	6.3%	3.3	0.1	3	7.1%	3.4	0.4
Chemistry	-	-	-	-	8	19.0%	3.2	0.4
Mechanics and energy	5	15.6%	3.5	0.2	5	11.9%	3.7	0.6
ICT, instruments and robotics	21	65.6%	4.1	0.3	20	47.6%	4.3	0.5
R&D technological intensity								
Low-intensity technology	2	6.3%	2.2	0.0	5	11.9%	2.6	0.2
Medium-low intensity technology	4	12.5%	3.4	0.6	4	9.5%	3.4	0.3
Medium-high intensity technology	5	15.6%	3.5	0.2	13	31.0%	3.4	0.5
High intensity technology	21	65.6%	4.1	0.3	20	47.6%	4.3	0.5
Degree of technological complexity								
Low	4	12.5%	2.2	0.5	7	16.7%	2.6	0.4
Average	7	21.9%	3.4	0.3	16	38.1%	3.4	0.5
High	21	65.6%	3.5	0.3	19	45.2%	3.4	0.5

Three basic assumptions:

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrator* projects are not connected among themselves, or in other words, the scores of *co-promotion projects' degree of novelty of innovation activities* are **independent** from the scores of the *individual projects' dimension iii*. The assumption of independent samples is thus **ensured**.[79]

- *Sampling of groups that are normally distributed*:

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether *dimension iii* **follows a normal distribution** in the *co-promotion* projects' group, as well as in the *individual* projects' group, the ***Central Limit Theorem*** is applied. It should be pointed out that there is a considerable sample of *co-promotion* projects ($n_{CP} = 42 > 30$) and that the execution of the Theorem proves this assumption. On the other hand, regarding individual projects, even though their sample is thinner ($n_{IP} = 32 > 30$), it was possible to determine, through the application of the ***Central Limit Theorem***, that the violation of this assumption does not have serious consequences.

- *Homogeneity of variance*:

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the *Levene*'s test is conducted, considering the following hypotheses:

H_0: variance in the *degree of novelty of innovation activities* dimension is equal in the two project typologies ($\delta_{Dimension\ iii\ CP}{}^2 = \delta_{Dimension\ iii\ IP}{}^2$).

H_a: variance in the *degree of novelty of innovation activities* dimension is different in the two project typologies ($\delta_{Dimension\ iii\ CP}{}^2 \neq \delta_{Dimension\ iii\ IP}{}^2$).

Test of Homogeneity of Variances

Degree of novelty of innovation activities

Levene Statistic	df1	df2	Sig.
3,128	1	72	,081

Levene $_{(1;72)} = 3.128$; *p-value* $= 0.081 > \alpha = 0.05$[80], therefore the null hypothesis (H_0) of the equality of variances is not rejected. In other words, it is assumed they are equal. In this regard, the dispersion of the *degree of novelty of innovation activities* dimension, measured by the variance, is not influenced by the two project typologies. ***Assumption confirmed***.

[79] Put differently, considering that the co-promotion projects are not the same as the individual projects, the *samples* are necessarily *independent*.

[80] In *Snedecor*'s F distribution tests, there are usually two degrees of freedom (*df*). The first one corresponds to the number of compared groups, *i.e.*, $k - 1 = 2 - 1 = 1$, and the second one to the dimension of the sample under analysis, i.e., $n - k = 74 - 2 = 72$. Therefore $df1 = 1$ e $df2 = 72$.

The *one-way ANOVA*[81] can thus be conducted.

The guiding hypotheses of the *one-way ANOVA* test are:

H_0: on average, the assessment on the *degree of novelty of innovation activities* dimension is equal in the *co-promotion* and *individual* projects ($\mu_{Dimension\ iii\ CP} = \mu_{Dimension\ iii\ IP} \Leftrightarrow \mu_{Dimension\ iii\ CP} - \mu_{Dimension\ iii\ IP} = 0$).

H_a: on average, the assessment on the *degree of novelty of innovation activities* dimension is different in the *co-promotion* and *individual* projects ($\mu_{Dimension\ iii\ CP} \neq \mu_{Dimension\ iii\ IP} \Leftrightarrow \mu_{Dimension\ iii\ CP} - \mu_{Dimension\ iii\ IP} \neq 0$).

ANOVA

Degree of novelty of innovation activities

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,015	1	,015	,032	,859
Within Groups	34,314	72	,477		
Total	34,329	73			

Since *p-value* = 0.859 > α = 0.05, then H_0 is not rejected. The *post-hoc*[82] tests show no **significant differences** between the assessment means of the two typologies in the *degree of novelty of innovation activities* dimension ($F_{(1;72)} = 0.032$; *p-value* = 0.859).

Robust Tests of Equality of Means

Degree of novelty of innovation activities

	Statistic[a]	df1	df2	Sig.
Welch	,034	1	71,942	,854
Brown-Forsythe	,034	1	71,942	,854

a. Asymptotically F distributed.

There is no statistical evidence to argue that, on average, assessment in the *degree of novelty of innovation activities*[83] differs between *co-promotion and individual Demonstrator* projects. As can be observed below, the means are identical, of approximately 3.8 for both project typologies. This means that the existence of collaborative R&D and of a higher intensity of technology transfer have no impact on (the rise of) the degree of novelty or on the production complexity of that same technology. That is to say that business organizations design, by themselves, completely innovative solutions in technological fields of high R&D intensity, without seeking the technical support of scientific and technological entities.

[81]Provided the assumptions were not confirmed, namely the normality one, the *Kruskal-Wallis H* non-parametric test would be conducted as an alternative.

[82] The *post-hoc* tests are conducted when the *one-way ANOVA* test for equality of means (*Welch* or *Brown-Forsythe*) suggests that there is at least one group with the mean different from the others. In this case, the *post-hoc* tests identify the sets of population groups which differ from one another, on average.

[83]*Degree of novelty of innovation activities* is a quantitative variable which encompasses scores between 1 (mediocre) and 5 (exceptional).

		Degree of novelty of innovation activities				
		Mean	Standard Deviation	Minimum	Median	Maximum
Project typology	Co-promotion	3,75	,76	2,40	3,80	5,00
	Individual	3,78	,59	2,20	4,00	4,60

VII.V – Variance analysis (ANOVA) – *Scope of innovation outputs and diffusion*

Key-question: Does project typology actually influence the performance in the *Scope of innovation outputs and diffusion* dimension? Do *co-promotion projects* have, on average, a better *ex-ante* assessment regarding technological diffusion?

Project typology	Individual Demonstrator				Co-promotion Demonstrator			
	N	% Total	$\overline{x}$	Std. Deviation	N	% Total	$\overline{x}$	Std. Deviation
Intellectual property registration								
No	16	50.0%	1.9	0.8	18	42.9%	2.4	0.7
Yes, one	15	46.9%	3.1	0.9	21	50.0%	3.5	0.5
Yes, more than one	1	3.1%	3.6	0.0	3	7.1%	3.9	0.7
Type of protection								
Not applicable	16	50.0%	2.1	0.3	17	40.5%	3.4	0.6
Patent	9	28.1%	3.4	0.6	17	40.5%	3.7	0.8
Trademark	5	15.6%	2.5	0.3	7	16.7%	3.5	0.3
Utility model	2	6.3%	3.3	1.1	1	2.4%	3.7	0.6
Design	-	-	-	-	-	-	-	-
Positive externalities								
Process	21	65.6%	2.2	0.9	20	47.6%	3.1	0.8
Consumer goods	4	12.5%	3.5	1.0	10	23.8%	2.6	0.8
Intermediate product	7	21.9%	2.9	1.0	12	28.6%	3.5	0.7
Effects of dissemination and promotion								
No	3	9.4%	1.4	0.9	3	7.2%	2.6	0.8
Yes, entails technology diffusion	14	43.8%	2.1	0.7	12	28.5%	2.3	0.8
Yes, entails technoscience diffusion	2	6.3%	3.2	0.6	8	19.1%	3.1	0.7
Yes, entails technology and technoscience diffusion	13	40.6%	3.2	0.8	19	45.2%	3.6	0.5
Economic valorization of results								
Plan with stand-alone activities of diffusion and dissemination of results	11	34.4%	1.7	0.7	17	40.5%	2.5	0.8
Consistent plan with foreseen activities, with great potential for the dissemination of results	21	65.6%	3.0	0.8	25	59.5%	3.5	0.7

Three basic assumptions:

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrator* projects are not connected among themselves, or in other words, the scores of *co-promotion projects' scope of innovation outputs and diffusion* are **independent** from the scores of the *individual projects' dimension iv*. The assumption of independent samples is thus **ensured**.[84]

- *Sampling of groups that are normally distributed*:

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether *dimension iv* **follows a normal distribution** in the *co-promotion* projects' group, as well as in the *individual* projects' group, the *Central Limit Theorem* is applied. It should be pointed out that there is a considerable sample of *co-promotion* projects ($n_{CP} = 42 > 30$) and that the execution of the Theorem proves this assumption. On the other hand, regarding individual projects, even though their sample is thinner ($n_{IP} = 32 > 30$), it was possible to determine, through the application of the *Central Limit Theorem*, that the violation of this assumption does not have serious consequences.

- *Homogeneity of variance*:

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the *Levene*'s test is conducted, considering the following hypotheses:

H_0: variance in the *scope of innovation outputs and diffusion* dimension is equal in the two project typologies ($\delta_{Dimension\ iv\ CP}{}^2 = \delta_{Dimension\ iv\ IP}{}^2$).

H_a: variance in the *scope of innovation outputs and diffusion* dimension is different in the two project typologies ($\delta_{Dimension\ iv\ CP}{}^2 \neq \delta_{Dimension\ iv\ IP}{}^2$).

Test of Homogeneity of Variances

Scope of innovation outputs and diffusion

Levene Statistic	df1	df2	Sig.
,655	1	72	,421

Levene $_{(1;72)} = 0.655$; *p-value* $= 0.421 > \alpha = 0.05$[85], therefore the null hypothesis (H_0) of the equality of variances is not rejected. In other words, it is assumed they are equal. In this regard, the dispersion of the *scope of innovation outputs and diffusion* dimension, measured by the variance, is not influenced by the two project typologies. ***Assumption confirmed***.

[84] Put differently, considering that the co-promotion projects are not the same as the individual projects, the *samples* are necessarily *independent*.

[85] In *Snedecor*'s F distribution tests, there are usually two degrees of freedom (*df*). The first one corresponds to the number of compared groups, *i.e.,* $k - 1 = 2 - 1 = 1$, and the second one to the dimension of the sample under analysis, i.e., $n - k = 74 - 2 = 72$. Therefore $df1 = 1$ e $df2 = 72$.

The *one-way ANOVA*[86] can thus be conducted. The guiding hypotheses of the *one-way ANOVA* test are:

H_0: on average, the assessment on the *scope of innovation outputs and diffusion* dimension is equal in *co-promotion* and *individual* projects ($\mu_{Dimension\ iv\ CP} = \mu_{Dimension\ iv\ IP} \Leftrightarrow \mu_{Dimension\ iv\ CP} - \mu_{Dimension\ iv\ IP} = 0$).

H_a: on average, the assessment on the *scope of innovation outputs and diffusion* dimension is different in the *co-promotion* and *individual* projects ($\mu_{Dimension\ iv\ CP} \neq \mu_{Dimension\ iv\ IP} \Leftrightarrow \mu_{Dimension\ iv\ CP} - \mu_{Dimension\ iv\ IP} \neq 0$).

ANOVA

Scope of innovation outputs and diffusion

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5,458	1	5,458	6,519	,013
Within Groups	60,286	72	,837		
Total	65,745	73			

Since *p-value* = 0.013 < α = 0.05, then H_0 is rejected. The *post-hoc*[87] tests show **statistical significance** to support (and argue) that, on average, the assessment in the *scope of innovation outputs and diffusion* dimension is **different between the two typologies** ($F_{(1;72)} = 6.519$; *p-value* = 0.013).

Robust Tests of Equality of Means

Scope of innovation outputs and diffusion

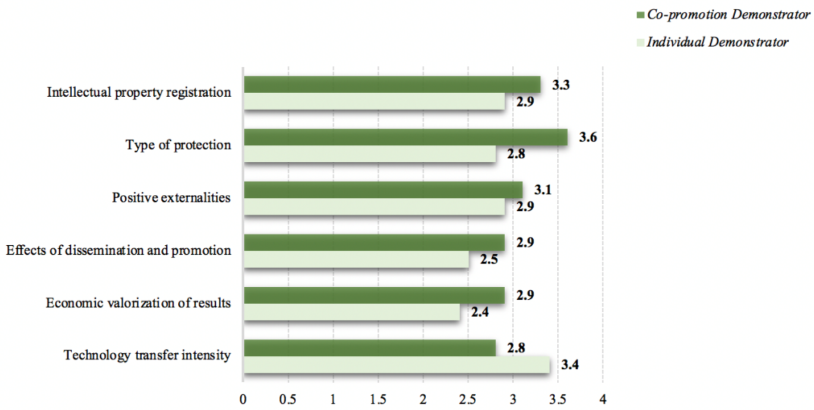
	Statistic[a]	df1	df2	Sig.
Welch	6,259	1	61,164	,015
Brown-Forsythe	6,259	1	61,164	,015

a. Asymptotically F distributed.

		Scope of innovation outputs and diffusion				
		Mean	Standard Deviation	Minimum	Median	Maximum
Project typology	Co-promotion	3,09	,85	1,30	3,25	4,40
	Individual	2,54	,99	,90	2,50	4,50

[86] In case the assumptions are not verified, namely the normality one, the *Kruskal-Wallis H* non-parametric test would be conducted as an alternative.

[87] The *post-hoc* tests are conducted when the *one-way ANOVA* test for equality of means (*Welch* or *Brown-Forsythe*) suggests that there is at least one group with the mean different from the others. In this case, the *post-hoc* tests identify the sets of population groups which differ from one another, on average.



Having ascertained the existence of a relationship between the two variables, it is interesting to interpret the measure of association, in this case *Eta* (given the type of variables). Knowing that this measure varies between 0 (*i.e.,* no relationship) and (*i.e.*, perfect relationship) and keeping *scope of innovation outputs and diffusion* as the dependent variable in the *ex-ante* assessment, then *Eta* = 0.676. Therefore, the **association** between the *scope of innovation outputs and diffusion*project typology* is **weak.**

Directional Measures

			Value
Nominal by Interval	Eta	Scope of innovation outputs and diffusion Dependent	,288
		Project typology Dependent	,672

VII.VI – Variance analysis (ANOVA) – *Impact on business competitiveness and economy*

Key-question: Does project typology actually influence the performance in the *impact on business competitiveness and economy* dimension? Do *co-promotion projects* have, on average, a better *ex-ante* assessment in strategic and economic terms?

Project typology	Individual Demonstrator				Co-promotion Demonstrator			
	N	% Total	$\overline{v}$	Std. Deviation	N	% Total	$\overline{v}$	Std. Deviation
Business strategy								
With no impact/No information available	-	-	-	-	-	-	-	-
Expansion of the current business, improving process efficiency	14	43.8%	3.5	0.6	9	21.4%	4.2	0.3
Expansion of the current business, enriching the current supply and/or reaching new customer segments	7	21.9%	4.0	0.3	11	26.2%	3.9	0.5
Expansion of the current business, reaching new customer segments and new markets	11	34.4%	4.1	0.4	22	52.4%	4.5	0.5
Propensity for international markets								
No	7	21.9%	3.5	0.7	4	9.5%	4.1	-
Yes, with little relevance to the company strategic guidelines	12	37.5%	3.8	0.6	16	38.1%	4.2	0.6
Yes, relevant to the company strategic guidelines	13	40.6%	3.9	0.4	22	52.4%	4.5	0.4
Contribution to national economy								
Low	5	15.6%	3.0	0.4	4	9.5%	3.7	0.3
Average	9	28.1%	3.8	0.5	10	23.8%	4.0	0.5
High	18	56.3%	4.0	0.4	28	66.7%	4.5	0.4
Contribution to the ENEI								
Null	-	-	-	-	-	-	-	-
Low	10	31.3%	4.0	0.5	10	23.8%	3.5	0.6
Average	16	50.0%	4.3	0.5	17	40.5%	3.8	0.4
Strong	6	18.8%	4.5	0.2	15	35.7%	4.3	0.5
Regional and sectorial convergence								
Not framed	-	-	-	-	-	-	-	-
Wild-card	6	18.8%	3.2	0.5	5	11.9%	3.6	0.5
Emergent	7	21.9%	3.5	0.6	14	33.3%	4.3	0.4
Core	19	59.4%	4.1	0.3	23	54.8%	4.5	0.4

Three basic assumptions:

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrator* projects are not connected among themselves, or in other words, the scores of *co-promotion projects' impact on business* *competitiveness and economy* are **independent** from the scores of the *individual projects' dimension v*. The assumption of independent samples is thus **ensured**.[88]

***- Sampling of groups that are normally distributed*:**

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether *dimension v* **follows a normal distribution** in the *co-promotion* projects' group, as well as in the *individual* projects' group, the ***Central Limit Theorem*** is applied. It should be pointed out that there is a considerable sample of *co-promotion* projects ($n_{CP} = 42 > 30$) and that the execution of the Theorem proves this assumption. On the other hand, regarding individual projects, even though their sample is thinner ($n_{IP} = 32 > 30$), it was possible to determine, through the application of the ***Central Limit Theorem***, that the violation of this assumption does not have serious consequences.

***- Homogeneity of variance*:**

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the **Levene's test** is conducted, considering the following hypotheses:

H_0: variance in the *impact on business competitiveness and economy* dimension is equal in the two project typologies ($\delta_{Dimension\ v\ CP}{}^2 = \delta_{Dimension\ v\ IP}{}^2$).

H_a: variance in the *impact on business competitiveness and economy* dimension is different in the two project typologies ($\delta_{Dimension\ v\ CP}{}^2 \neq \delta_{Dimension\ v\ IP}{}^2$).

Test of Homogeneity of Variances

Impact on business competitiveness and economy

Levene Statistic	df1	df2	Sig.
,041	1	72	,841

Levene $_{(1;72)} = 0.041$; *p-value* $= 0.841 > \alpha = 0.05$[89], therefore the null hypothesis (H_0) of the equality of variances is not rejected. In other words, it is assumed they are equal. In this regard, the dispersion of the *impact on business competitiveness and economy* dimension, measured by the variance, is not influenced by the two project typologies. ***Assumption confirmed***.

The *one-way ANOVA*[90] can thus be conducted. The guiding hypotheses of the *one-way ANOVA* test are:

[88] Put differently, considering that the co-promotion projects are not the same as the individual projects, the *samples* are necessarily *independent*.

[89] In *Snedecor*'s F distribution tests, there are usually two degrees of freedom (*df*). The first one corresponds to the number of compared groups, *i.e.,* $k - 1 = 2 - 1 = 1$, and the second one to the dimension of the sample under analysis, i.e., $n - k = 74 - 2 = 72$. Therefore *df1* = 1 e *df2* = 72.

[90] Provided the assumptions were not verified, namely the normality one, the *Kruskal-Wallis H* non-parametric test would be conducted as an alternative.

H_0: on average, the assessment on the *impact on business competitiveness and economy* dimension is equal in *co-promotion* and *individual* projects ($\mu_{Dimension\ v\ \mathrm{CP}} = \mu_{Dimension\ v\ \mathrm{IP}} \Leftrightarrow \mu_{Dimension\ v\ \mathrm{CP}} - \mu_{Dimension\ v\ \mathrm{IP}} = 0$).

H_a: on average, the assessment on the *impact on business competitiveness and economy* dimension is different in the *co-promotion* and *individual* projects ($\mu_{Dimension\ v\ \mathrm{CP}} \neq \mu_{Dimension\ v\ \mathrm{IP}} \Leftrightarrow \mu_{Dimension\ v\ \mathrm{CP}} - \mu_{Dimension\ v\ \mathrm{IP}} \neq 0$).

ANOVA

Impact on business competitiveness and economy

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4,815	1	4,815	17,847	,000
Within Groups	19,425	72	,270		
Total	24,240	73			

Since *p-value* = 0.000 < α = 0.05, then H_0 is rejected. The *post-hoc*[91] tests show **statistical significance** to support (and argue) that, on average, the assessment in the *impact on business competitiveness and economy* dimension is **different between the two typologies** ($F_{(1;72)} = 17.847$; *p-value* = 0.000).

Robust Tests of Equality of Means

Impact on business competitiveness and economy

	Statistic[a]	df1	df2	Sig.
Welch	17,449	1	63,851	,000
Brown-Forsythe	17,449	1	63,851	,000

a. Asymptotically F distributed.

Directional Measures

			Value
Nominal by Interval	Eta	Impact on business competitiveness and economy Dependent	,446
		Project typology Dependent	,678

VII.VII –*T* test for two independent samples– *Project merit*

Scope: the *t* parametric test for two independent samples is applied in order to compare the means of a quantitative (*dependent*) variable in two independent populations defined by a qualitative (*independent)* variable.

In this case, considering the analysis model of this thesis, the primary goal is to understand whether collaborative R&D is a rapid and effective pathway towards the success of innovation projects. In this regard, these are the starting questions: ***Does the merit of the innovative project differ between individual and co-promotion***

[91] The *post-hoc* tests are conducted when the *one-way ANOVA* test for equality of means (*Welch* or *Brown-Forsythe*) suggests that there is at least one group with the mean different from the others. In this case, the *post-hoc* tests identify the sets of population groups which differ from one another, on average.

Demonstrators? Does the science-industry cooperation boost substantially higher merit?

Since the *project merit* variable is a quantitative (*dependent*) variable and the project typology (*predictor)* is a nominal qualitative variable, which encompasses *two independent groups* (*i.e., individual* projects and *co-promotion* projects), **the *t* test for two independent samples** is conducted in order to ascertain whether, on average, the attained merit is different in *ex-ante* assessment.

While conducting a *t* test for two independent samples, ***three basic assumptions*** must be considered, so that it is correctly applied and statistical inference can be made:

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrator* projects are not connected among themselves, or in other words, the merit scores of *co-promotion projects* are **independent** from the *individual projects'* merit scores. The assumption of independent samples is thus ensured.[92]

- *Sampling of groups that are normally distributed*:

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether project merit **follows a normal distribution** in the *co-promotion* projects' group, as well as in the *individual* projects' group, the most robust normality test is conducted – the ***Shapiro-Wilk* test**[93].

The *Normal Q-Q Plot* shows the quantiles of the observed distribution and the quantiles that one would expect to see if the data were normally distributed (*i.e.,* mean of 0 and standard deviation of 1). For a normal distribution, the points fall along a (roughly) straight line in the *Normal Q-Q Plot,* and the deviations from the normal distribution are scattered randomly around the Y= 0 line, in the ***Detrended Normal Q-Q Plot***.

SPSS generates *outputs* for the two categories of the *project typology* predictor. The first category (**Project_typology=1**) pertains to *co-promotion Demonstrator* projects and is the first one to be analyzed.

[92] Put differently, considering that the *co-promotion projects* are not the same as the *individual projects*, the *samples* are necessarily *independent*.
[93] Since each one of the samples (*i.e.,* project typologies) is no larger than 50, the normality test *Shapiro-Wilk* (n ≤ 50) is conducted, instead of the *Kolmogorov-Smirnov* normality test for big samples.

Key-question: *Does project merit follow a normal distribution in the group of co-promotion Demonstrator projects?*

The hypotheses of the ***Shapiro-Wilk* normality test** are the following:

H_0: project merit follows a normal distribution in the group of *co-promotion* Demonstrators projects (H_0: Project merit $\cap$ N (μ,σ)).

H_a: project merit does not follow a normal distribution in the group of *co-promotion* Demonstrator projects (H_a: Project merit $\not\cap$ N (μ,σ)).

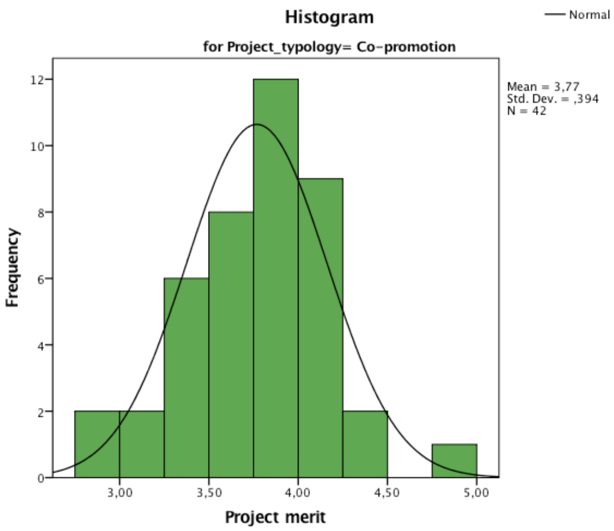
Tests of Normality

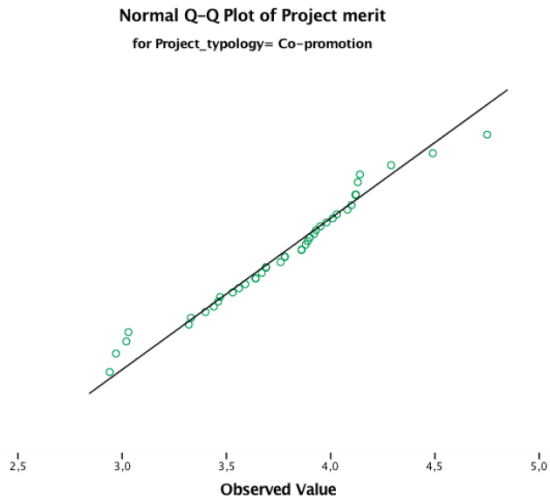
	Project typology	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Project merit	Co-promotion	,101	42	,200*	,973	42	,409
	Individual	,083	32	,200*	,983	32	,876

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

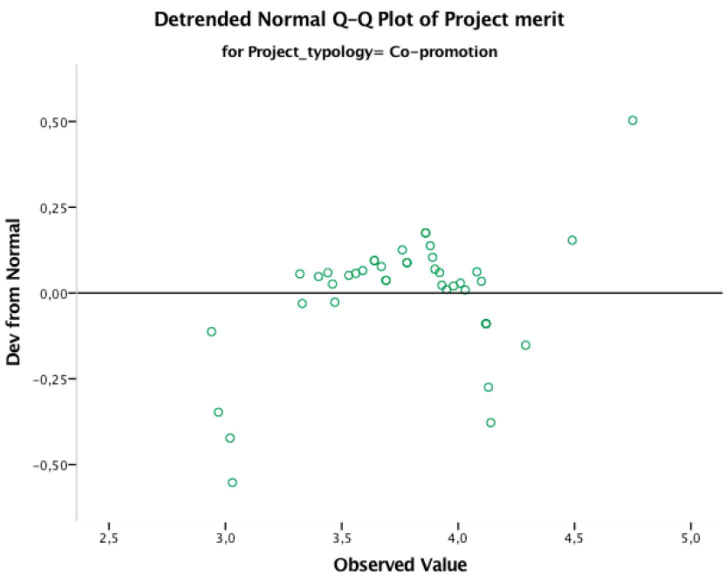
Since *p-value* = 0.409 > α = 0.05, then is not H_0 rejected.

The *Normal Q-Q Plot* shows that the points fall along an almost straight line, which indicates that the distribution for the *co-promotion projects* category is roughly Normal.





In the *Detrended Normal Q-Q plot*, it is possible to observe that the deviations from normality are scattered randomly around the Y= 0 line.



There is no statistical evidence to argue that the merit achieved by co-promotion Demonstrator projects does not follow a normal distribution ($SW_{(42)} = 0.973$; *p-value* = 0.409)[94]. Therefore, it is assumed that **merit is normally distributed in the co-promotion typology.**

The second category (**Project_typology=2**) pertains to *individual Demonstrator* projects, analyzed below.

Key-question: *Does project merit follow a normal distribution in the group of individual Demonstrator projects?*

The hypotheses of the *Shapiro-Wilk* normality test are the following:

H_0: project merit follows a normal distribution in the group of *individual* Demonstrators projects (H_0: Project merit $\cap$ N (μ,σ)).
H_a: project merit does not follow a normal distribution in the group of *individual* Demonstrator projects (H_a: Project merit $\cap$ N (μ,σ)). /

Tests of Normality

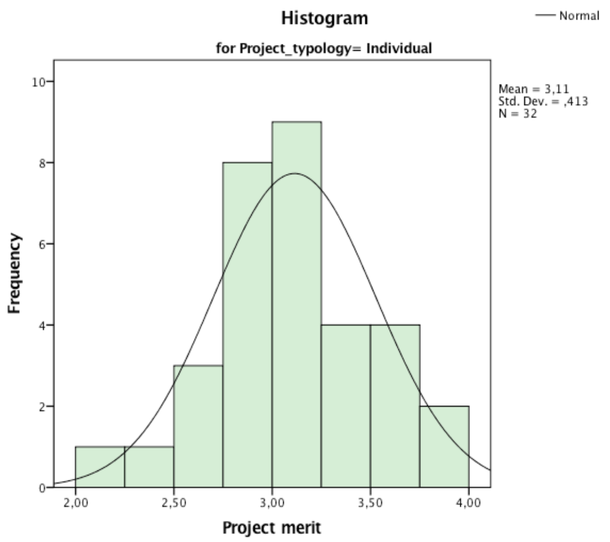
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Project typology	Statistic	df	Sig.	Statistic	df	Sig.
Project merit	Co-promotion	,101	42	,200*	,973	42	,409
	Individual	,083	32	,200*	,983	32	,876

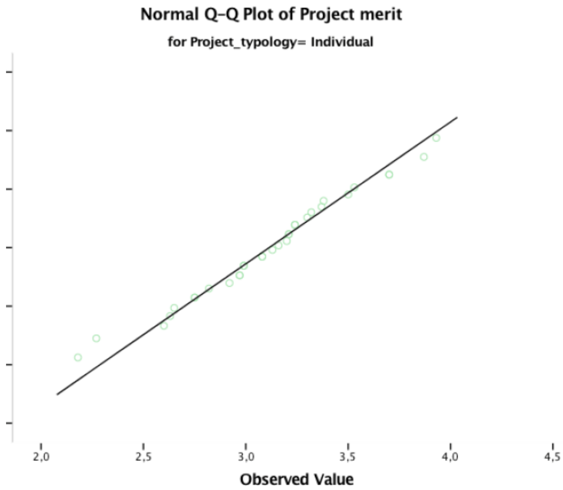
*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Since *p-value*= 0.876 > α = 0.05, then H_0 is not rejected.

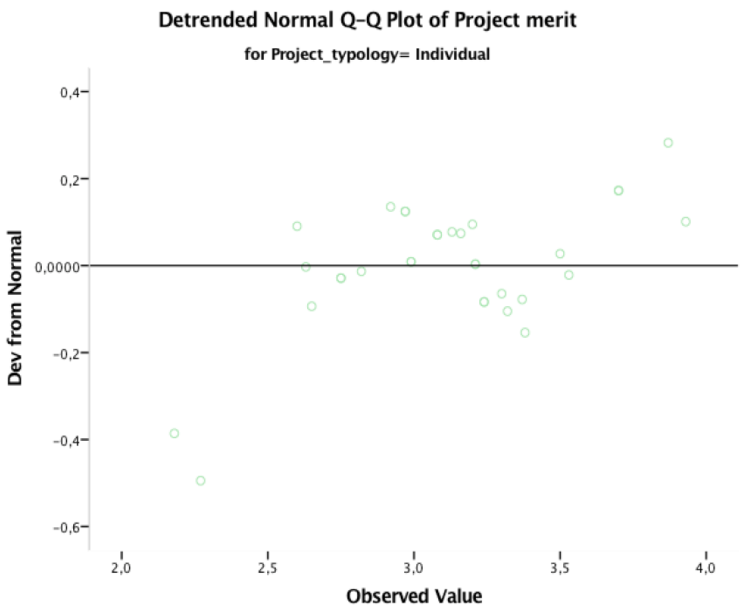
[94] The degrees of freedom convey the sample size n=42 (since 42 *co-promotion* Demonstrator projects are being treated).

The *Normal Q-Q Plot* shows that the points fall along an almost straight line, which indicates that the distribution for the *individual project's* category is roughly Normal.





In the *Detrended Normal Q-Q Plot*, it is possible to observe that the deviations from the Normal distribution are randomly scattered around the Y= 0 line.



There is no statistical evidence to argue that the merit achieved by individual Demonstrator projects does not follow a normal distribution ($SW_{(32)} = 0.983$; *p-value* = 0.876)[95]. Therefore, it is assumed that **merit is normally distributed in the individual typology.**

[95] The degrees of freedom convey the sample size n=32 (since 32 *individual* Demonstrator projects are being analyzed).

This assumption could have been checked in a simpler way, since both sample sizes are larger than 30 ($n_{CP} = 42 > 30$ e $n_{IP} = 32 > 30$). It is hence possible to confirm the assumption by conducting the *Central Limit Theorem*.

***- Homogeneity of variance*:**

Considering that the output presents two *t* tests - one for when the variances of the project merit are equal (*Equal variances assumed*) and the other for when they are unequal (*Equal variances not assumed*) -, the appropriate one must be selected, in accordance with the *Levene*'s test for the homogeneity of variance. In practical terms, it tests homoscedasticity or homogeneity of the variances (*i.e.,* the degree of dispersion).

Key-question: *Is the deviation around the mean significantly different between the two project typologies?*

Hypotheses of the *Levene's test* for the homogeneity of variances:

H_0: the variance of the *co-promotion Demonstrator* projects' merit is equal to the variance of the *individual Demonstrator* projects' variance (${\delta_{ProjectMerit\ CP}}^2 = {\delta_{ProjectMerit\ IP}}^2$).

H_a: the variance of the *co-promotion Demonstrator* projects' merit is unequal to the variance of *individual Demonstrator* projects' merit (${\delta_{ProjectMerit\ CP}}^2 \neq {\delta_{ProjectMerit\ IP}}^2$).

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Project merit	Based on Mean	,024	1	72	,876
	Based on Median	,024	1	72	,877
	Based on Median and with adjusted df	,024	1	71,800	,877
	Based on trimmed mean	,022	1	72	,883

		Project merit					
		Mean	Standard Deviation	Variance	Minimum	Median	Maximum
Project typology	Co-promotion	3,77	,39	,16	2,94	3,82	4,75
	Individual	3,11	,41	,17	2,18	3,15	3,93

Given that the project merit variable follows a normal distribution, the test statistic is calculated based on mean (*Based on Mean*). Therefore, since *p-value* $= 0.876 > \alpha = 0.05$, then H_0 is not rejected.

There is no statistical evidence to argue that the variances of the Demonstrator projects' merit are significantly different between the two project typologies (Levene $_{(1;72)} = 0.024$; *p-value* $= 0.876$). The dispersion of project merit, measured by variance, is not influenced by the two Demonstrator project typologies.

Having confirmed the three classical assumptions, the ***t* test for two independent samples** may then be conducted[96].The guiding hypotheses of the *t* test are:

H_0: on average, the merit of the *co-promotion Demonstrator* projects is equal to the merit of the *individual Demonstrator* projects ($\mu_{\text{Project Merit CP}} = \mu_{\text{Project Merit IP}} \Leftrightarrow \mu_{\text{Project Merit CP}} - \mu_{\text{Project Merit IP}} = 0$).

H_a: on average, the merit of the *co-promotion Demonstrator* projects is unequal to the merit of the *individual Demonstrator* projects ($\mu_{\text{Project Merit CP}} \neq \mu_{\text{Project Merit IP}} \Leftrightarrow \mu_{\text{Project Merit CP}} - \mu_{\text{Project Merit IP}} \neq 0$).

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Project merit	Equal variances assumed	,024	,876	6,936	72	,000	,65435	,09433	,46629	,84240
	Equal variances not assumed			6,892	65,190	,000	,65435	,09495	,46473	,84396

Assuming the variances are equal, as was confirmed in the *Levene*'s test, then *p-value* = 0.000 < α = 0.05, and H_0 is rejected. Ergo, there is statistical evidence to argue that, on average, the merit achieved by *co-promotion Demonstrators* is different from the one attained by the *individual Demonstrators* ($t_{(72)} = 6.936$; *p-value* = 0.00).

It is ascertained with 95.0% of confidence that the mean difference between *co-promotion* and *individual* projects' merit is comprised between 0.47 and 0.84.

Group Statistics

	Project typology	N	Mean	Std. Deviation	Std. Error Mean
Project merit	Co-promotion	42	3,7681	,39371	,06075
	Individual	32	3,1137	,41276	,07297

Directional Measures

			Value
Nominal by Interval	Eta	Project merit Dependent	,633
		Project typology Dependent	,938

Summary of the *ex-ante* assessment's guiding hypotheses:

***H_1*:** *Co-promotion* projects are expected to present better-elaborated work plans, scientific and technological methodologies and investment plans. ☑

***H_2*:** *Co-promotion* projects are expected to be comprised by entities that are better qualified and more adequate to the designated innovation, with no need to subcontract resources external to the team. ☑

***H_3*:** *Co-promotion* projects are expected to potentiate innovations with higher degree of novelty in fields of high-intensity technology. ☒

[96]Provided the assumptions had not been validated, the *Mann-Whitney U* nonparametric test would have been conducted as an alternative.

H₄: *Co-promotion* projects are expected to be more prone to generating positive externalities for economy, with more preeminent effects of dissemination and valuation of results. ☑

H₅: *Co-promotion* projects are expected to contribute more predominantly to national competitiveness and national convergence, following primarily Portugal 2020's priority domains. ☑

		Project merit
Project merit	Pearson Correlation	1
	Sig. (2-tailed)	
	N	42
Coherence and rationality	Pearson Correlation	,663**
	Sig. (2-tailed)	,000
	N	42
Intensity and adequacy of R&D inputs	Pearson Correlation	,757**
	Sig. (2-tailed)	,000
	N	42
Degree of novelty of innovation activities	Pearson Correlation	,157
	Sig. (2-tailed)	,321
	N	42
Scope of innovation outputs and diffusion	Pearson Correlation	,551**
	Sig. (2-tailed)	,000
	N	42
Impact on business competitiveness and economy	Pearson Correlation	,568**
	Sig. (2-tailed)	,000
	N	42

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

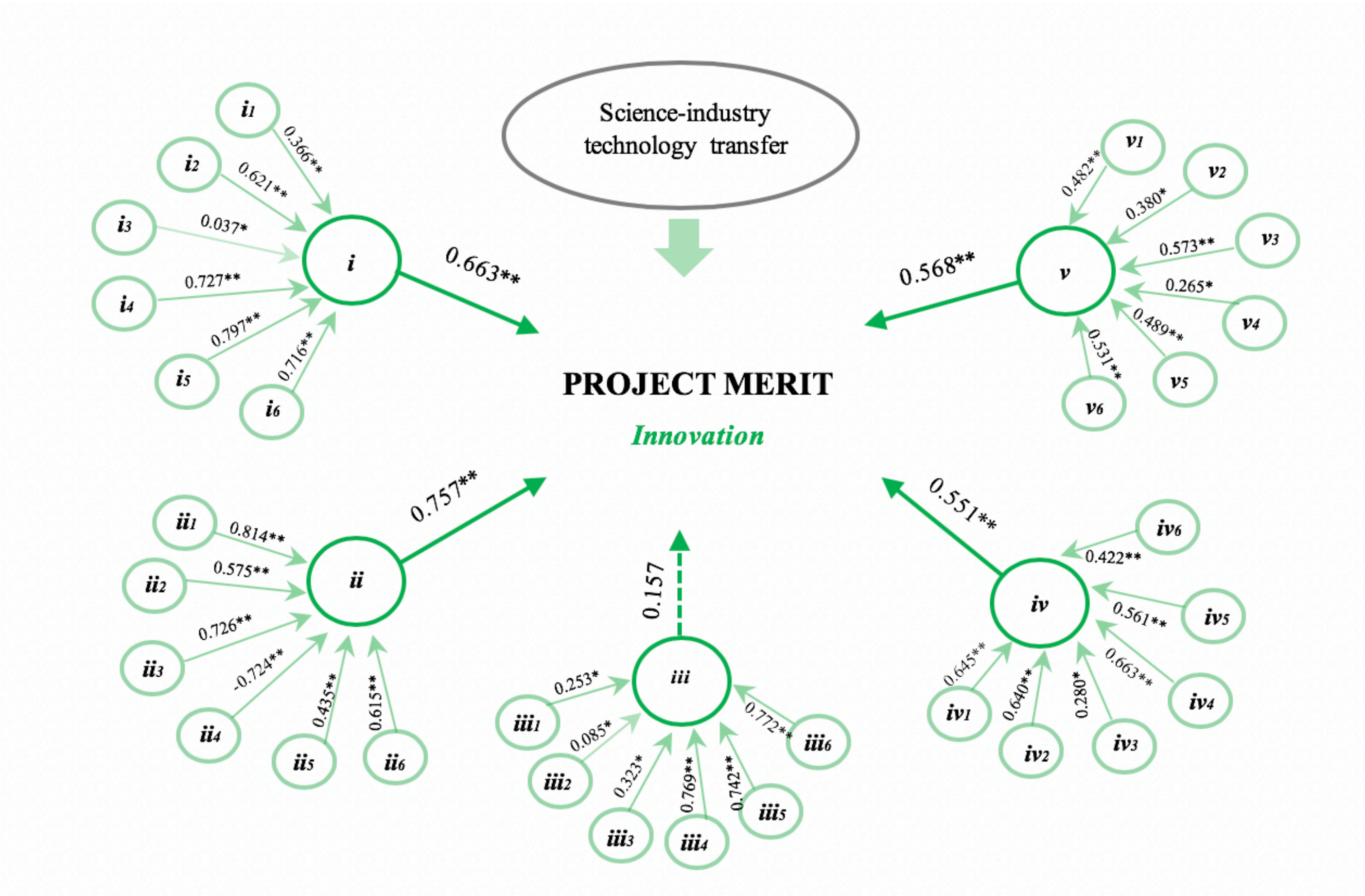
		Project merit
Project merit	Pearson Correlation	1
	Sig. (2-tailed)	
	N	32
Coherence and rationality	Pearson Correlation	,805**
	Sig. (2-tailed)	,000
	N	32
Intensity and adequacy of R&D inputs	Pearson Correlation	,716**
	Sig. (2-tailed)	,000
	N	32
Degree of novelty of innovation activities	Pearson Correlation	,282
	Sig. (2-tailed)	,118
	N	32
Scope of innovation outputs and diffusion	Pearson Correlation	,405*
	Sig. (2-tailed)	,022
	N	32
Impact on business competitiveness and economy	Pearson Correlation	,656**
	Sig. (2-tailed)	,000
	N	32

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Having assessed the Demonstrator projects' application proposals, it was possible to determine that in virtually all dimensions of analysis, **the cooperation with technological entities fostered more cohesive projects**, **which are also more prepared** for the stages of technological development and commercialization.

Below is a diagram representing the relationships that were observed and their influence on the Demonstrator projects.

Diagram summarizing the *ex-ante* assessment of the Demonstrator projects (2015-2019)



** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Source: Own design based on data processed in SPSS.

Appendix VIII – *Ad-interim/Ex-post* assessment: statistical analysis of results

VIII.I –Variance analysis (ANOVA) – *Innovation readiness*

Key-question: Does project typology actually influence the performance in the innovation readiness dimension? Do co-promotion projects have, on average, a better *ex-post assessment* regarding its preparation and development stage?

- Independent samples (i.e., project typologies):

Individual and *co-promotion Demonstrator* projects are not connected among themselves, or in other words, the scores of *co-promotion projects' innovation readiness* are **independent** from this criterion's scores in *individual projects*. The assumption of independent samples is thus **ensured.**

- *Sampling of groups that are normally distributed:*

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether the *innovation readiness* criterion **follows a normal distribution** in the co-promotion projects' group, as well as in the *individual* projects' group, the **Central Limit Theorem** is applied. It should be pointed out that there is a considerable sample of *co-promotion* projects ($n_{CP} = 42 > 30$) and that the execution of the Theorem proves this assumption. On the other hand, regarding individual projects, even though their sample is thinner ($n_{IP} = 32 > 30$), it was possible to determine, through the application of the **Central Limit Theorem**, that the violation of this assumption does not have serious consequences.

- *Homogeneity of variance*:

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* the degree of dispersion) the ***Levene's test*** is conducted, considering the following hypotheses:

H_0: variance in the *innovation readiness* dimension is equal in the two project typologies ($\delta_{Criteria\ IRI\ CP}{}^2 = \delta_{Criteria\ IRI\ IP}{}^2$).

H_a: variance in the *innovation readiness* dimension is different in the two project typologies ($\delta_{Criteria\ IRI\ CP}{}^2 \neq \delta_{Criteria\ IRI\ IP}{}^2$).

Test of Homogeneity of Variances

Innovation readiness

Levene Statistic	df1	df2	Sig.
,081	1	72	,777

Levene $_{(1;72)} = 0.081$; *p-value* $= 0.777 > \alpha = 0.05$, therefore the null hypothesis (H_0) of the equality of variances is not rejected. In other words, it is assumed they are equal. In this regard, the dispersion of the *innovation readiness* dimension, measured by the variance, is not influenced by the two project typologies. **Assumption confirmed**.

The ***one-way ANOVA*** can thus be conducted.

The guiding hypotheses of the one-way *ANOVA test* are:

H_0: on average, the assessment on the *innovation readiness* dimension is equal in *co-promotion* and *individual projects* ($\mu_{Criteria\ IRI\ CP} = \mu_{Criteria\ IRI\ IP} \Leftrightarrow \mu_{Criteria\ IRI\ CP} - \mu_{Criteria\ IRI\ IP} = 0$).

H_a: on average, the assessment on the *innovation readiness* dimension is different in *co-promotion* and *individual projects* ($\mu_{Criteria\ IRI\ CP} \neq \mu_{Criteria\ IRI\ IP} \Leftrightarrow \mu_{Criteria\ IRI\ CP} - \mu_{Criteria\ IRI\ IP} \neq 0$).

ANOVA

Innovation readiness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20,711	1	20,711	40,228	,000
Within Groups	37,068	72	,515		
Total	57,779	73			

Since *p-value* = 0.00 < α = 0.05, then H_0 is rejected. The *post-hoc* tests show **statistical significance** to support (and argue) that, on average, the assessment in the *innovation readiness* dimension is **different between the two typologies** ($F_{(1;72)}$ = 40.228; *p-value* = 0.000).

Robust Tests of Equality of Means

Innovation readiness

	Statistic[a]	df1	df2	Sig.
Welch	40,131	1	66,576	,000
Brown-Forsythe	40,131	1	66,576	,000

a. Asymptotically F distributed.

		Innovation readiness				
		Mean	Standard Deviation	Minimum	Median	Maximum
Project typology	Co-promotion	3,79	,71	1,70	3,80	5,00
	Individual	2,72	,72	1,40	2,70	4,50

Directional Measures

			Value
Nominal by Interval	Eta	Innovation readiness Dependent	,599
		Project typology Dependent	,710

VIII.II – *T Test* for two typologies – *Innovation management*

Key-question: Does project typology actually influence the performance in the *innovation management* dimension? Do co-promotion project have, on average, a better *ex-post assessment* in terms of their management skills?

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrators* are not connected among themselves, or in other words, the scores of *co-promotion projects' innovation management* are **independent** from the scores of this criterion in *individual projects.* The assumption of independent samples is thus **ensured**.[97]

[97] Put differently, considering that the co-promotion projects are not the same as the individual projects, the samples are necessarily independent.

- Sampling of groups that are normally distributed:

Having applied the ***Central Limit Theorem***, it was observed that the two samples are taken from normally distributed groups. **Assumption confirmed**.

- Homogeneity of variance:

In order to test the homoscedasticity or homogeneity of the variances (i.e., THE degree of dispersion) the ***Levene's test*** is conducted, considering the following hypotheses:

H_0: variance in the *innovation management* dimension is equal in the two project typologies ($\delta_{Criteria\ IMI\ CP}{}^2 = \delta_{Criteria\ IMI\ IP}{}^2$).

H_a: variance in the *innovation management* dimension is different in the two project typologies ($\delta_{Criteria\ IMI\ CP}{}^2 \neq \delta_{Criteria\ IMI\ IP}{}^2$).

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Innovation management	Based on Mean	8,110	1	72	,006
	Based on Median	8,244	1	72	,005
	Based on Median and with adjusted df	8,244	1	63,366	,006
	Based on trimmed mean	8,007	1	72	,006

Levene $_{(1;72)} = 8.110$; *p-value* $= 0.006 \leq \alpha = 0.05$, therefore the null hypothesis (H_0) is rejected and it is assumed that the variances are different. But, the *t* test can thus be conducted. The *t* test has the following guiding hypotheses:

H_0: on average, the assessment on the *innovation management* dimension is equal in *co-promotion* and *individual* projects ($\mu_{Criteria\ IMI\ CP} = \mu_{Criteria\ IMI\ IP} \Leftrightarrow \mu_{Criteria\ IMI\ CP} - \mu_{Criteria\ IMI\ IP} = 0$).

H_a: on average, the assessment on the *innovation management* dimension is different in the *co-promotion* and *individual projects* ($\mu_{Criteria\ IMI\ CP} \neq \mu_{Criteria\ IMI\ IP} \Leftrightarrow \mu_{Criteria\ IMI\ CP} - \mu_{Criteria\ IMI\ IP} \neq 0$).

Since *p-value* $= 0.00 < \alpha = 0.05$, then H_0 is rejected. It was determined, with 95.0% of confidence, that the different means in innovation management between co-promotion and individual projects vary 0.3 and 1.0.

		Innovation management				
		Mean	Standard Deviation	Minimum	Median	Maximum
Project typology	Co-promotion	2,72	,89	1,30	2,65	4,80
	Individual	2,07	,53	,80	2,00	3,00

Directional Measures

			Value
Nominal by Interval	Eta	Innovation management Dependent	,399
		Project typology Dependent	,526

VIII.III –Variance analysis (ANOVA) – *Market potential*

Key-question: Does project typology actually influence performance in the *market potential* dimension? Do *co-promotion Demonstrators* have, on average, a better *ex-post* assessment, regarding the technologies' access to the market?

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrator* projects are not connected among themselves, or in other words, the scores of *co-promotion projects' market potential* are **independent** from the scores of this criterion in *individual projects*. The assumption of independent samples is thus **ensured.**[98]

- *Sampling of groups that are normally distributed*:

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether the *market potential* criterion **follows a normal distribution** in the *co-promotion* projects' group, as well as in the *individual* projects' group, the ***Central Limit Theorem*** ($n > 30$) is applied. **Assumption confirmed**.

- *Homogeneity of variance*:

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the ***Levene's test*** is conducted, considering the following hypotheses:

H_0: variance in the *market potential* dimension is equal in the two project typologies ($\delta_{Criteria\ MPI\ CP}{}^2 = \delta_{Criteria\ MPI\ \ IP}{}^2$).

H_a: variance in the *market potential* dimension is different in the two project typologies ($\delta_{Criteria\ MPI\ CP}{}^2 \neq \delta_{Criteria\ MPI\ IP}{}^2$).

Test of Homogeneity of Variances

Market potential

Levene Statistic	df1	df2	Sig.
,255	1	72	,615

Levene $_{(1;72)} = 0.255$; *p-value* $= 0.615 > \alpha = 0.05$[99], therefore the null hypothesis (H_0) is not rejected. In other words, it is assumed they are equal. ***Assumption confirmed***.

The *one-way ANOVA*[100] *test* can thus be conducted. The guiding hypotheses of the *one-way ANOVA* test are:

H_0: on average, the assessment on the *market potential* dimension is equal in *co-promotion* and *individual* projects ($\mu_{Criteria\ MPI\ CP} = \mu_{Criteria\ MPI\ IP} \Leftrightarrow \mu_{Criteria\ MPI\ CP} - \mu_{Criteria\ MPI\ IP} = 0$).

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98 Put differently, considering that the co-promotion projects are not the same as the individual projects, the *samples* are necessarily *independent*.

99 In *Snedecor*'s F distribution tests, there are usually two degrees of freedom (*df*). The first one corresponds to the number of compared groups, *i.e.,* $k - 1 = 2 - 1 = 1$, and the second one to the dimension of the sample under analysis, i.e., $n - k = 74 - 2 = 72$. Therefore $df1 = 1$ e $df2 = 72$.

100 Provided the assumptions were not verified, namely the normality one, the *Kruskal-Wallis H* non-parametric test would be conducted as an alternative.

H_a: on average, the assessment on the *market potential* dimension is different in the *co-promotion* and *individual* projects ($\mu_{Criteria\ MPI\ CP} \neq \mu_{Criteria\ MPI\ IP} \Leftrightarrow \mu_{Criteria\ MPI\ CP} - \mu_{Criteria\ MPI\ IP} \neq 0$).

ANOVA

Market potential

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3,683	1	3,683	14,307	,000
Within Groups	18,534	72	,257		
Total	22,216	73			

Since *p-value* = 0.00 < α = 0.05, then H_0 is rejected. The *post-hoc* tests show **statistical significance** to support (and argue) that, on average, the assessment in the *market potential* dimension is **different between the two typologies** ($F_{(1;72)} = 14.307$; *p-value* = 0.000).

Top 10 of the technologies with higher innovation potential in the Demonstrator projects (2015-2019)

Rank **by IPI**	**Purposes of the demonstration**	**Innovation description**	**No. of innovations[101]**	**IRI *score***	**IMI *score***	**MPI *score***	**IPI *score***
Demo C parts	Demonstration of the water assisted injection molding technology, applied to high-performance pieces.	Project in the field of mechanics and energy aimed at developing an eco-sustainable technology for the production of hollow pieces with a complex geometry. It sought to replace metallic parts, as well as to produce tubes with a rectangular internal section.	Two	5.0 (High)	4.8 (High)	3.7 (High)	**4.7 (High)**
In2Dig	Demonstration of the digital platform for cyber-physical virtualization of industrial production cells.	Project in the field of ICT aimed at unblocking and feeding the obsolete manufacturing systems, boost optimization in quality, cost and productivity, as well as the adaptive/evolving capacity. This was accomplished through the integration of the *ploughings* platform.	Two	4.8 (High)	4.5 (High)	3.5 (High)	**4.3 (High)**
HS. Helios	Data communication and portability in Health.	Project in the field of ICT aimed at tackling the constraints caused by the lack of interoperability between the existing systems and the dependency on external factors. It sought to centralize the transmissions of the users/costumer's clinical and demographic data.	Two	4.8 (High)	4.3 (High)	3.0 (Medium)	**4.0 (High)**
Coopweld	Demonstration of robotic welding industrial cell for the production of steel assemblies for buildings.	Project in the field of robotics and automation, which sought to demonstrate that the combination of robots, sensors and automatic offline programming enables the use of robotic welding in the manufacture of small structural assemblies in a competitive way (exclusive for SMEs).	Three	4.9 (High)	3.8 (High)	3.4 (High)	**4.0 (High)**

[101] For a minimum of ***one*** technological innovation and a maximum of ***three*** innovations.

Gnesis	Graphenest's new engineered system and its implementation solutions.	Project in the field of chemistry aimed at applying an innovative technology based on a method of graphite exfoliation in a liquid environment.	Two	4.5 (High)	3.5 (Medium)	3.7 (High)	**3.9 (High)**
HS. Register	Traceability in Health	Project in the field of ICD aimed at ensuring the traceability of the actions of multiple players in health processes, both inside the institutions and in their connection to external entities.	One	4.5 (High)	3.3 (Medium)	3.5 (High)	**3.8 (High)**
Magline	Development and industrial validation of the fabrication processes of TMR sensors.	The lack of industrial production capacity has prevented the adoption of the most recent sensors (TMR) in commercial applications. For this reason, this project sought to optimize and demonstrate their viability.	One	4.7 (High)	3.5 (Medium)	3.0 (High)	**3.7 (High)**
PreSlabTec	Demonstration of the innovative construction system for fully precast voided slab of high performance.	Project in the field of materials and construction technologies, aimed at tackling the existing gaps in the precast structural systems for pavements application in buildings.	Two	3.9 (Medium)	4.3 (High)	2.9 (Medium)	**3.7 (High)**
WGR[102]	Demonstration of the *WiiGo Retail* product action plan.	Project in the field of ICT aimed at the implementation of pilot tests of the *WiiGo Retail* product in the retail industry, as well as at the gathering of costumers and users' feedback.	One	4.5 (High)	3.0 (Medium)	3.2 (Medium)	**3.6 (High)**
Cork.a.tex-yarm	Demonstration of wire with high incorporation of cork.	Project in the field of materials technologies which aimed at the scalability, optimization and industrial validity of the innovative concept of wire coated in micro agglomerated-cork.	One	4.8 (High)	2.5 (Medium)	3.4 (High)	**3.6 (High)**

[102] *WGR* is the only individual Demonstrator project in the *Top 10* of technologies with high innovation potential.

VIII.IV - *T* test for two typologies – *Innovator's ability*

Key-question: Does project typology actually influence the performance in the *innovation ability* dimension? Do co-promotion projects have, on average, a better *ex-post* assessment in terms of their innovative behavior?

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrators* are not connected among themselves, or in other words, the scores of *co-promotion projects' innovators ability* are **independent** from the scores of this criterion in *individual projects.* The assumption of independent samples is thus ensured.[103]

- Sampling of groups that are normally distributed:

Having applied the ***Central Limit Theorem***, it was observed that the two samples are taken from normally distributed groups. Assumption confirmed.

- *Homogeneity of variance*:

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the ***Levene's test*** is conducted, considering the following hypotheses:

H_0: variance in the *innovator ability* dimension is equal in the two project typologies ($\delta_{Criteria\ IAI\ CP}{}^2 = \delta_{Criteria\ IAI\ IP}{}^2$).

H_a: variance in the *innovator ability* dimension is different in the two project typologies ($\delta_{Criteria\ IAI\ CP}{}^2 \neq \delta_{Criteria\ IAI\ IP}{}^2$).

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Innovator's ability	Based on Mean	33,058	1	72	,000
	Based on Median	22,984	1	72	,000
	Based on Median and with adjusted df	22,984	1	54,347	,000
	Based on trimmed mean	32,723	1	72	,000

Levene $_{(1;72)} = 33.058$; *p-value* $= 0.000 \leq \alpha = 0.05$, therefore the null hypothesis (H_0) is rejected and it is assumed that the variances are different.

But, the *t test*[104] can be conducted. The *t* test has the following guiding hypotheses:

H_0: on average, the assessment on the *innovator ability* dimension is equal in *co-promotion* and *individual* projects ($\mu_{Criteria\ IAI\ CP} = \mu_{Criteria\ IAI\ IP} \Leftrightarrow \mu_{Criteria\ IAI\ CP} - \mu_{Criteria\ IAI\ IP} = 0$).

[103] Put differently, considering that the co-promotion projects are not the same as the individual projects, the samples are necessarily independent.

[104] In case the assumptions are not confirmed, namely normality, the non-parametric test *Kruskal-Wallis H* would be conducted as an alternative.

H_a: on average, the assessment on the *innovator ability* dimension is different in the *co-promotion* and *individual projects* ($\mu_{Criteria\ IAI\ CP} \neq \mu_{Criteria\ IAI\ IP} \Leftrightarrow \mu_{Criteria\ IAI\ CP} - \mu_{Criteria\ IAI\ IP} \neq 0$).

Since *p-value* = 0.000 $\leq \alpha = 0.05$ then H_0 is rejected. In other words, *co-promotion* projects display more capacity to innovate ($t_{(59.376)} = 6.030$).

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Innovator's ability	Equal variances assumed	33,058	,000	5,495	72	,000	,91176	,16591	,58101	1,24250
	Equal variances not assumed			6,030	59,376	,000	,91176	,15121	,60923	1,21429

It is ascertained with 95.0% of confidence that the mean difference between *co-promotion* and *individual* projects, regarding the ability to innovate is comprised between 0.6 and 1.2.

Group Statistics

	Project typology	N	Mean	Std. Deviation	Std. Error Mean
Innovator's ability	Co-promotion	42	2,6024	,87527	,13506
	Individual	32	1,6906	,38467	,06800

It was observed that *Eta* = 0.544, which indicates that the **association** between o *innovator's ability*project typology* is **moderate**.

Directional Measures

			Value
Nominal by Interval	Eta	Innovator's ability Dependent	,544
		Project typology Dependent	,701

VIII.V – *T* test for two typologies – *Innovator's environment*

Key-question: Does project typology actually influence the performance in the *innovator environment* dimension? Do co-promotion Demonstrators have, on average, a better *ex-post* assessment regarding their development and exploitation environment?

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrators* are not connected among themselves, or in other words, the scores of *co-promotion projects' innovator environment* are

independent from the scores of this criterion in *individual projects.* The assumption of independent samples is thus **ensured.**[105]

- Sampling of groups that are normally distributed:

Having applied the *Central Limit Theorem*, it was observed that the two samples are taken from normally distributed groups. **Assumption confirmed**.

***- Homogeneity of variance*:**

In order to test the homoscedasticity or homogeneity of the variances (*i.e.,* degree of dispersion), the *Levene's* test is conducted, considering the following hypotheses:

H_0: variance in the *innovator environment* is equal in the two project typologies ($\delta_{Criteria\ IEI\ CP}{}^2 = \delta_{Criteria\ IEI\ IP}{}^2$).

H_a: variance in the *innovator environment* dimension is different in the two project typologies ($\delta_{Criteria\ IEI\ CP}{}^2 \neq \delta_{Criteria\ IEI\ IP}{}^2$).

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Innovator's environment	Based on Mean	3,228	1	72	,077
	Based on Median	3,422	1	72	,068
	Based on Median and with adjusted df	3,422	1	65,266	,069
	Based on trimmed mean	3,382	1	72	,070

Levene $_{(1;72)}$ = 3.228; *p-value* = 0.077 > α = 0.05, therefore the null hypothesis (H_0) is not rejected and it is assumed that the variances are equal. The *t test*[106] can thus be conducted.

The *t* test has the following guiding hypotheses:

H_0: on average, the assessment on the *innovator environment* dimension is equal in *co-promotion* and *individual* projects ($\mu_{Criteria\ IEI\ CP} = \mu_{Criteria\ IEI\ IP} \Leftrightarrow \mu_{Criteria\ IEI\ CP} - \mu_{Criteria\ IEI\ IP} = 0$).

H_a: on average, the assessment in the *innovator environment* criterion is different in *co-promotion* and *individual* Demonstrators ($\mu_{Criteria\ IEI\ CP} \neq \mu_{Criteria\ IEI\ IP} \Leftrightarrow \mu_{Criteria\ IEI\ CP} - \mu_{Criteria\ IEI\ IP} \neq 0$).

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Innovator's environment	Equal variances assumed	3,228	,077	3,548	72	,001	,82560	,23271	,36170	1,28949
	Equal variances not assumed			3,727	71,314	,000	,82560	,22152	,38394	1,26725

[105] Put differently, considering that the co-promotion projects are not the same as the individual projects, the samples are necessarily independent.

[106] In case the assumptions are not confirmed, namely normality, the non-parametric test *Kruskal-Wallis H* would be conducted as an alternative.

Since *p-value* = 0.001 ≤ α = 0.05, then H_0 is rejected. In other words, *co-promotion* projects were developed in environments that are more promising for the success of the innovations ($t_{(72)} = 3.548$).

Group Statistics

	Project typology	N	Mean	Std. Deviation	Std. Error Mean
Innovator's environment	Co-promotion	42	3,0381	1,12855	,17414
	Individual	32	2,2125	,77449	,13691

It was observed that *Eta* = 0.386, which indicates that the association between *innovator's environment*project typology* is **moderate**.

Directional Measures

			Value
Nominal by Interval	Eta	Innovator's environment Dependent	,386
		Project typology Dependent	,546

VIII.VI –*T* test for two independent samples – Degree of success

In this case, considering the analysis model of this thesis, the primary goal is to understand whether collaborative R&D is a rapid and effective pathway towards the success of innovation projects. In this regard, these are the starting questions: ***Does the success of the innovative project differ between individual and co-promotion Demonstrators, on average? Does science-industry cooperation boost a substantially higher degree of success in the market?***

Three basic assumptions:

- *Independent samples* (*i.e.,* project typologies):

Individual and *co-promotion Demonstrator* projects are not connected among themselves, or in other words, the merit scores of *co-promotion projects* are **independent** from the *individual projects'* merit scores. The assumption of independent samples is thus ensured.[107]

***- Sampling of groups that are normally distributed*:**

In order to ascertain whether the two samples are drawn from groups that are normally distributed, that is to say, whether project merit **follows a normal distribution** in the *co-promotion* projects' group, as well as in the *individual* projects' group, the most robust normality test is conducted – the ***Shapiro-Wilk* test**[108].

[107] Put differently, considering that the *co-promotion projects* are not the same as the *individual projects*, the *samples* are necessarily *independent*.
[108] Since each one of the samples (*i.e.,* project typologies) is no larger than 50, the normality test *Shapiro-Wilk* (n ≤ 50) is conducted, instead of the *Kolmogorov-Smirnov* normality test for big samples.

The *Normal Q-Q Plot* shows the quantiles of the observed distribution and the quantiles that one would expect to see if the data were normally distributed (*i.e.,* mean of 0 and standard deviation of 1). For a normal distribution, the points fall along a (roughly) straight line in the *Normal Q-Q Plot,* and the deviations from the normal distribution are scattered randomly around the Y= 0 line, in the *Detrended Normal Q-Q* Plot. SPSS generates *outputs* for the two categories of the *project typology* predictor. The first category (**Project_typology=1**) pertains to *co-promotion Demonstrator* projects and is the first one to be analyzed.

Key-question: *Does degree of success follow a normal distribution in the group of co-promotion Demonstrator projects?*

The hypotheses of the *Shapiro-Wilk* normality test are the following:

H_0: degree of success follows a normal distribution in the group of *co-promotion* Demonstrators projects (H_0: Degree of success $\cap$ N (μ,σ)).

H_a: degree of success does not follow a normal distribution in the group of *co-promotion* Demonstrator projects (H_a: Degree of success $\not\cap$ N (μ,σ)).

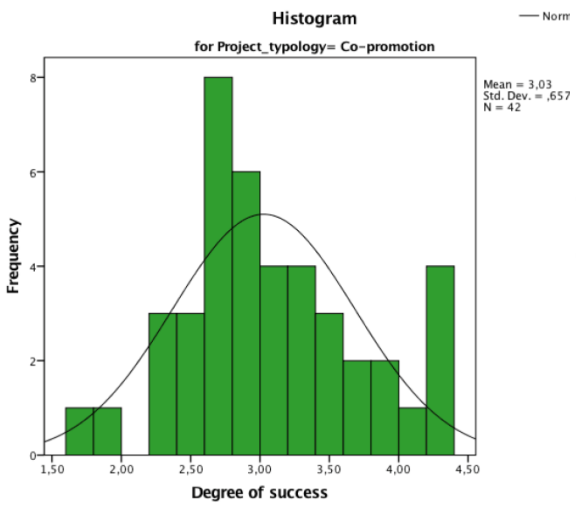
Tests of Normality

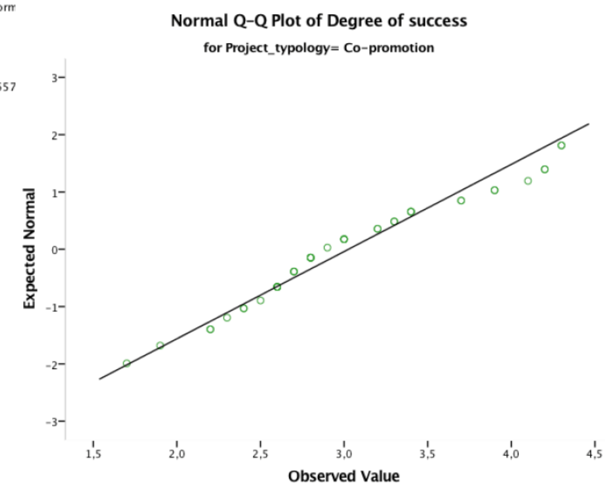
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Project typology	Statistic	df	Sig.	Statistic	df	Sig.
Degree of success	Co-promotion	,135	42	,053	,957	42	,115
	Individual	,163	32	,031	,955	32	,198

a. Lilliefors Significance Correction

Since *p-value*= 0.115 > α = 0.05, then H_0 is not rejected.

The *Normal Q-Q Plot* shows that the points fall along an almost straight line, which indicates that the distribution for the *individual project's* category is roughly Normal.





There is no statistical evidence to argue that the merit achieved by *co-promotion Demonstrator* projects does not follow a normal distribution (SW $_{(42)}$ = 0.973; *p-value* = 0.409)[109]. Therefore, it is assumed that **the degree of success is normally distributed in the co-promotion typology.**

The second category (**Project_typology=2**) pertains to *individual Demonstrator* projects, analyzed below.

Key-question: *Does degree of success follow a normal distribution in the group of individual Demonstrator projects?*

The hypotheses of the *Shapiro-Wilk* normality test are the following:

H_0: degree of success follows a normal distribution in the group of *individual* Demonstrators projects (H_0: Project merit $\cap$ N (μ,σ)).

H_a: degree of success does not follow a normal distribution in the group of *individual* Demonstrator projects (H_a: Project merit $\not\cap$ N (μ,σ)).

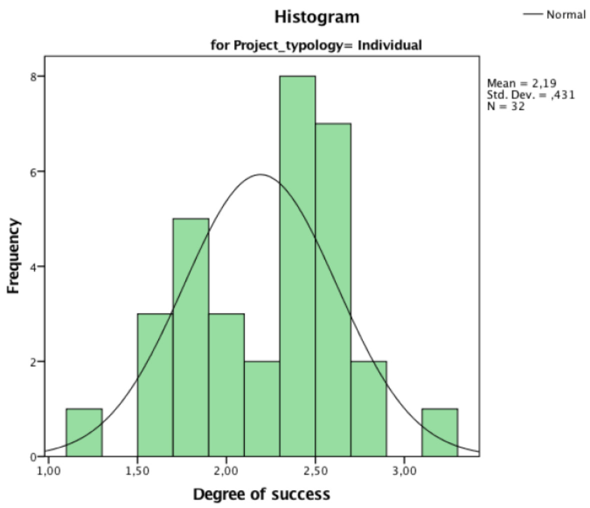
Tests of Normality

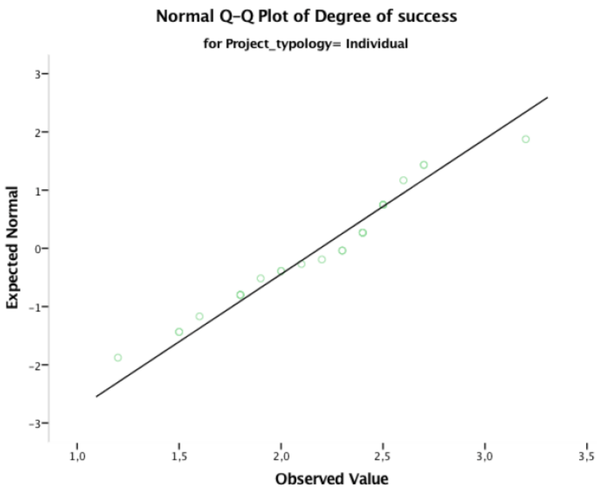
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Project typology	Statistic	df	Sig.	Statistic	df	Sig.
Degree of success	Co-promotion	,135	42	,053	,957	42	,115
	Individual	,163	32	,031	,955	32	,198

a. Lilliefors Significance Correction

Since *p-value* = 0.198 > α = 0.05, then H_0 is not rejected.

The *Normal Q-Q Plot* shows that the points fall along an almost straight line, which indicates that the distribution for the *individual project's* category is roughly Normal.





[109] The degrees of freedom convey the sample size n=42 (since 42 *co-promotion* Demonstrator projects are being treated).

There is no statistical evidence to argue that the success achieved by individual Demonstrator projects does not follow a normal distribution ($SW_{(32)} = 0.955$; *p-value* = 0.198)[110]. Therefore, it is assumed that the **degree of success is normally distributed in the individual typology.**

***- Homogeneity of variance*:**

Considering that the output presents two *t* tests – one for when the variances of the project merit are equal (*Equal variances assumed*) and the other for when they are unequal (*Equal variances not assumed*) –, the appropriate one must be selected, in accordance with the ***Levene*'s test** for the homogeneity of variance.

Key-question: *Is the deviation of degree of success around the mean significantly different between the two project typologies?*

Hypotheses of the *Levene*'s test for the homogeneity of variances:

H_0: the variance of the *co-promotion Demonstrator* projects' success is equal to the variance of the *individual Demonstrator* projects' variance ($\delta_{Degree\ of\ success\ CP}{}^2 = \delta_{Degree\ of\ success\ IP}{}^2$).

H_a: the variance of the *co-promotion Demonstrator* projects' success is unequal to the variance of *individual Demonstrator* projects' success ($\delta_{Degree\ of\ success\ CP}{}^2 \neq \delta_{Degree\ of\ success\ IP}{}^2$).

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Degree of success	Based on Mean	5,054	1	72	,028
	Based on Median	3,969	1	72	,050
	Based on Median and with adjusted df	3,969	1	62,434	,051
	Based on trimmed mean	5,008	1	72	,028

Given that the degree of success variable follows a normal distribution, the test statistic is calculated based on mean (*Based on Mean*). Therefore, since *p-value* = 0.028 $\leq \alpha = 0.05$, then H_0 is rejected ($Levene_{(1;72)} = 5.054$; *p-value* = 0.028). The dispersion of the degree of success, measured by variance, is therefore influenced by the two Demonstrator project typologies.

Having checked the three classical assumptions, the ***t* test for two independent samples** may then be conducted[111].

[110] The degrees of freedom convey the sample size n=32 (since 32 projects are being treated).
[111] Provided the assumptions had not been validated, the *Mann-Whitney U* nonparametric test would have been conducted as an alternative.

The guiding hypotheses of the *t* test are:

H_0: on average, the degree of success of the *co-promotion Demonstrator* projects is equal to the degree of success of the *individual Demonstrator* projects ($\mu_{\text{Degree of success CP}} \neq \mu_{\text{Degree of success IP}} \Leftrightarrow \mu_{\text{Degree of success CP}} - \mu_{\text{Degree of success IP}} \neq 0$).

H_a: on average, the degree of success of the *co-promotion Demonstrator* projects is unequal to the merit of the *individual Demonstrator* projects ($\mu_{\text{Degree of success CP}} \neq \mu_{\text{Degree of success IP}} \Leftrightarrow \mu_{\text{Degree of success CP}} - \mu_{\text{Degree of success IP}} \neq 0$).

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Degree of success	Equal variances assumed	5,054	,028	6,240	72	,000	,83557	,13391	,56862	1,10251
	Equal variances not assumed			6,591	70,585	,000	,83557	,12678	,58275	1,08838

Assuming the variances are different, as was verified in the *Levene*'s test, then: *p-value* = 0.000 < α = 0.05. As such, H_0 is rejected.

There is, therefore, statistical evidence to argue that, on average, the degree of success achieved by *co-promotion Demonstrators* is higher than the one attained by the *individual* ones ($t_{(70.585)} = 6.591$; *p-value* = 0.000).

Directional Measures

			Value
Nominal by Interval	Eta	Degree of success Dependent	,592
		Project typology Dependent	,787

Summary of the *ad-interim/ex-post* assessment's guiding hypotheses:

H_A: *Co-promotion* projects are expected to exhibit levels of innovation readiness that are more advanced and closer to the stage of commercial use, displaying higher innovation potential. ☑

H_B: *Co-promotion* projects are expected to show stronger capacities of R&D and knowledge management, exhibiting higher innovation potential.☑

H_C: *Co-promotion* projects are expected to generate more added value and more socioeconomic benefits to the market, displaying higher innovation potential. ☑

H_D: *Co-promotion* projects are expected to have greater capacity to generate new ideas and turn them into solutions that might respond to market demands, showing increased organizational capacity of innovation. ☑

H_E: *Co-promotion* projects are expected to mobilize and disseminate more learning resources and knowledge, exhibiting greater organizational capacity of innovation. ☑