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FEP FACULDADE DE ECONOMIA UNIVERSIDADE DO PORTO

DO FIRMS' CHARACTERISTICS INFLUENCE THE TYPES OF INNOVATION ADOPTED BY SMES APPLYING TO EUROPEAN FUNDS?

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Dissertation

Master in Management

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2021

Biographic Note

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As part of the master's degree, she attended a curricular internship at Yunit Consulting from October 2020 to April 2021. In this internship, Ana Luisa had the opportunity to work directly with Portuguese SMEs and with experienced consultants in the field of European Funds.

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Acknowledgements

First of all, I would like to show my gratitude to my supervisors, Professors Catarina Roseira and João Ribeiro, that accepted to take on this challenge with me and taught me so much during the process. Also, to Professor Vitorino, who was always available to clarify my doubts.

To my parents, Arminda and Fernando, for making this journey possible and always supporting me every step of the way.

To my sister, Bárbara, for always being such a great role model that pushed me to become a better person and invest in my education.

To Pedro for his endless patience and for believing in me even when I didn't. He made the process easier and encouraged me to always try my best.

To Yunit Consulting for all the support and availability during the internship that gave the mote and data to develop this thesis.

Finally, to all my friends.

Abstract

This study address the following research question: "Do firms' characteristics influence the types of innovation adopted by SMEs that are applying to European Funds?". This question has emerged from a literature gap in the field of associating internal factors like firm size, age, exports and others with the type of innovation performed by companies.

The value of this study relies on three main points. First, the study of whether there is an effect of certain characteristics such as exports, employees' qualifications among others on the type of innovation, is still an underexplored topic in the literature. Second, there was an opportunity to use a unique and complete dataset to provide updated information on companies that innovated in the past six years. Lastly, it provides information about the patterns of innovation types present in those applications and possible relationships with the results found.

For this purpose, this study is based on self-reported data extracted from a sample made by more than one hundred applications made by a consulting company. The companies analysed are Portuguese SMEs applying to the Incentive Programme of *Inovação Produtiva* (part of Portugal 2020).

After applying three different binary regression models, the study concludes that: (1) process innovation is the type that shows statistical evidence of a relationship to the company characteristics, with variables such as age and being a manufacturing company playing an important role; (2) exports showed a positive impact on the adoption of product innovation and (3) the adoption of both innovations suggested, even if with some reservations, a relation with the competitive scope of the company and the manufacturing sector. The conclusions also show that innovation types such as organisational and marketing are widely adopted, but it may be speculated that this results from the attempt by companies to attain a higher project score.

Keywords: Innovation, Innovation Types, SMEs, European Funds

JEL-Codes: O31, O32

Resumo

Este estudo aborda a seguinte questão de investigação: "As características das empresas influenciam os tipos de inovação adotados pelas PMEs que se candidatam a Fundos Europeus?". Esta questão teve origem numa lacuna da literatura, no âmbito da associação de fatores internos como o tamanho da empresa, idade, exportações e outros, com o tipo de inovação realizada.

O valor deste estudo depende de três pontos principais. Em primeiro lugar, o estudo do efeito de certas características como exportações, qualificação média, entre outras, sobre o tipo de inovação, é um tema pouco explorado na literatura. Em segundo lugar, foi possível utilizar um conjunto de dados exclusivos e completo que fornecem informações atualizadas sobre empresas que inovaram nos últimos seis anos. Por fim, o estudo destaca certos padrões de inovação encontrados nestas candidaturas e possíveis conexões com os resultados.

Para isso, este estudo baseia-se em dados autorrelatados, extraídos de uma amostra de mais de uma centena de candidaturas elaboradas por uma consultora. As empresas analisadas são PME portuguesas candidatas ao Programa de Incentivos de Inovação Produtiva (integrado no Portugal 2020).

Após a aplicação de três modelos de regressão binária diferentes, conclui-se que: (1) a inovação de processo é o tipo que apresenta significância estatística confirmando o efeito de certas caracteristicas na adoção deste tipo de inovação: variáveis como idade e ser uma empresa da insústria transformadora têm impacto; (2) as exportações mostraram impacto positivo na adoção de inovação de produto e (3) a adoção simultanea de inovação de processo e produto sugeriu, com algumas ressalvas, uma relação com o âmbito competitivo da empresa e do setor das industrias transformadoras. As conclusões mostram ainda que tipos de inovação como organizacional e de marketing são amplamente adotados, sendo porém possível especular que em causa está uma forma de as empresas tentarem obter uma maior pontuação no projeto.

Palavras-chave: Inovação, Tipos de Inovação, PMEs, Fundos Europeus

JEL-Codes: O31, O32

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1. Introduction

Innovation is considered by many the foundation for firms' sustainable competitive advantage (Cho & Pucik, 2005; Mugharbil & Weheba, 2018). The term "innovation" has been widely discussed, and its linkage to small and medium enterprises (SMEs) performance is the focus of several management studies (Laforet, 2011; Shouyu, 2017). Within the identified types of innovation by OECD/Eurostat (2005) - product, process, marketing and organisational - the impacts on firms performance are different (Sipos & Ionescu, 2015) and this heterogeneity highlights the importance of understanding what is behind each type of innovation, and what factors should be taken into consideration when strategically managing a company. Being the management of innovation crucial to small businesses (Mugharbil & Weheba, 2018), this study aims to contribute to the literature by understanding if firm characteristics (e.g., firm size, age, exports and others) influence the type of innovation undertaken by SMEs that are applying to European Funds.

Recently, the European Commission (2020c) considered SMEs the economy's engine. The globalization of markets resulted in higher levels of competition, fast changes in technology, and smaller product lifecycles (Laforet, 2011), leading countless companies, mainly SMEs, to focus on innovation to stand out from the competition. Facing market failures previously addressed in the literature (Ayyagari et al., 2017), the European Union provides funding programmes to SMEs, which aim to contribute to the development of the European Area (European Commission).

The application process for these funds/programs requires having a detailed plan of action, which makes companies seek help from consulting companies. That said, this study uses data from a small consulting company working with applications of Portuguese SMEs to European Funds. This study addresses the following research question: "Do firms' characteristics influence the types of innovation adopted by SMEs that are applying to European Funds?". This question has emerged from a literature gap in the field of associating the internal factors/characteristics with the type of innovation made by companies.

Although the factors that seem to differentiate companies that were more likely to innovate are already presented in an annual report released by the European Commission (2019), no linkage is made to innovation types. Besides, this data also points out the types of innovation more performed in an aggregate mode; however, it has a large lag in terms of release. The

referred report of 2018/2019 had data relative to the years of 2014-2016. A similar study is found with Demircioglu et al. (2019) studying the sources of innovation and their types. Nevertheless, the focus of these authors was on external sources of innovation such as universities and suppliers, without a complete analysis of firm internal characteristics.

The value of this research relies on three main points. First, it studies whether there is an effect of certain characteristics such as international sales, employees' qualifications among others on the type of innovation, a topic underexplored in the literature. Second, it uses a unique and complete dataset that enables access to updated information on companies that innovated and applied to European Funds in the past six years. Lastly, it provides information about the patterns of innovation types present in those applications and possible relationships with the results found.

Therefore, studying whether firms' characteristics influence innovation types can be considered relevant as it broadens the literature and the knowledge that there is about the innovation process, as well as it can become useful for managers to make conscious management of innovation, as it contributes to the comparison of innovation types, rather than focusing on the wide concept of innovation.

For this purpose, this study will be based on a sample of clients' projects elaborated by a consulting company for Portuguese SMEs applying mostly to the European Program of Horizon 2020 and uses binary regressions models to identify if there is an impact of the studied characteristics on the innovation type. In this case, it was used applications to an incentive programme as a proxy of the types of innovation performed by the companies. In addition, to better read the results of the sample in terms of patterns, a cluster analysis will be conducted and will complement the statistical models' results.

Following this introduction, this report will be divided into four more chapters. Chapter 2 presents the literature review of the main topics and concepts, such as SMEs, innovation and its types, reasons, and challenges. Still in this section, an analysis of the factors that influence innovation in SMEs is conducted, followed by the presentation of the research framework and hypotheses of the study. Chapter 3 presents the methodology, as well as the sample and the variables in the study. Chapter 4 discusses the results of the study. Chapter 5 presents the conclusions and limitations of the study findings and gives some suggestions for improvements in future research.

2. Literature Review

This chapter reviews the main concepts related to the topic, the relevant studies on SMEs, innovation, and the factors that affect innovation in SMEs. Then, the research framework and the hypotheses of the study are presented.

2.1. Small and Medium Enterprises

Small and Medium Enterprises (SMEs) have been a concept widely discussed and differently defined in the literature (Berisha & Pula, 2015). It has been suggested distinct criteria to define it and even with the same criteria, the threshold is not consensual between institutions and countries (Berisha & Pula, 2015; Hossain & Kauranen, 2016). Pobobsky (1992) cites an International Labour Organisation's study, which points out that in 75 countries existed more than 50 definitions with differences in the used terminology. Even since then, the variability of SME definitions has hardly been mitigated (Berisha & Pula, 2015).

According to the European Union (2003, p. 4) on an Extract of Article 2 of the annexe to Recommendation 2003/361/EC:

> *"The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million."*

In Europe, SMEs were further classified into three major groups represented in Table 1: first, micro-enterprises with less than ten employees and with a maximum of €2 million annual turnovers; second, small enterprises with less than fifty employees and with a maximum of €10 million annual turnovers; and third, medium-sized enterprises with less than two hundred and fifty employees and with maximum €50 million annual turnovers. Although, in more complex structures, individual analysis is recommended to certify an appropriate classification (European Commission, 2020c).

Table 1: Thresholds (Article 2)

SME Category	**Headcount:** annual work unit (AWU)	**Annual turnover**	***Or***	**Annual balance sheet total**
Medium-sized	< 250	≤ EUR 50 million	*Or*	≤ EUR 43 million
Small	< 50	≤ EUR 10 million	*Or*	≤ EUR 10 million
Micro	< 10	≤ EUR 2 million	*Or*	≤ EUR 2 million

Source: European Commission (2020c, p. 11).

According to Cicea et al. (2019), the relevance of studying SMEs comes from several aspects: (1) Gross domestic product (GDP) and unemployment are influenced by SMEs (only excepting the centralized economies); (2) With the world's economy in constant change, the national economies' interdependencies and hard recovery after the crisis have led to the increasing relevance of the SMEs based on their flexibility and capability to adapt to an ever-changing environment (Bayarçelik et al., 2014); (3) The framework of entrepreneurship, a vital element defining a competitive economy, is represented by SMEs; (4) It was found that, despite different intensities in different areas and cultures, SMEs have an important role in fostering technical progress in society and innovation in the economy.

Moreover, a cursory review of the available statistics (OCDE, 2019), reveals that 99% of all businesses are SMEs, which generate around 60% of employment and are responsible for 50% to 60% of value-added in the area of the OECD. Therefore, according to the same source, they are "essential drivers of economic and social well-being" (OCDE, 2019, p. 5), as they are crucial contributors to the creation of jobs and economic development. Moreover, SMEs are considered, in a recent European Union's guide, the engine of the European Union as they stimulate innovation and entrepreneurship, essential factors to competitiveness (European Commission, 2020c).

2.2. Innovation

The management of Innovation is crucial to small businesses (Mugharbil & Weheba, 2018) and, in fact, studies demonstrate that smaller businesses are a crucial driving force of innovation, and can be so innovative as larger companies (Laforet, 2011). The literature on innovation is extensive and diverse (Bayarçelik et al., 2014; Mugharbil & Weheba, 2018) with a long way of trying to define it and understand the impact it has on companies.

Since the late 1880s, the term "innovation" has been used in some reports to indicate something uncommon, however, none of those studies was as relevant to the literature as the work developed by Schumpeter. Moreover, according to Śledzik (2013), Schumpeter described the role of innovation ("new combinations") and entrepreneurial spirit in the growth of the economy. Besides, Bigliardi et al. (2011, p. 2) cite Schumpeter's vision of innovation as "the creation of new combinations, that is, the introduction of a new good, of a new quality of a good, or a new method of production, the opening of a new market, the conquest of a new source of supply of raw materials or half-manufactured goods, and finally, the carrying out of the new organization of any industry".

Decades later, in the last Oslo Manual released by OECD/Eurostat (2018, p. 22), innovation is defined as:

> *"A new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)."*

According to the same source, this definition is "inherently subjective", but its application is "fairly objective" (OECD/Eurostat, 2018, p. 22), with the use of points of reference in terms of novelty and utility. Likewise, Edwards-Schachter (2018) suggests that in general, the most consensual understanding of the innovation's nature is related to the idea of "novelty" involving not only the creation but also the effective execution of the ideas that are afterwards converted into products, services or improved business functions. Summing up, this author states innovative nature results from the combination of invention, novelty, and change.

Moreover, it is important to distinguish the concept of invention from innovation. When there is the creation of an idea, but the criteria of successful application into a new product or process is not fulfilled, that is considered an invention. Only the first try to take it out into practice is what is called innovation. They are sometimes linked but, in most cases, there is a significant time lag between them (Fagerberg, 2003).

2.2.1. Why do Firms Innovate?

According to OECD/Eurostat (2018), the main motivation for innovation is to enhance firm performance by reducing costs or increasing demand. Moreover, the importance of innovation for competitiveness and economic performance is often described as uncontroversial (Lenzi & Perucca, 2020), and is considered by many as the foundation for sustainable competitive advantage and growth (Mugharbil & Weheba, 2018). Several studies find a positive association between the capability to innovate and the performance of the business (Gunday et al., 2011). Other studies such as Cho and Pucik (2005) suggest that only combining innovation and quality resulted in higher profitability.

Combining all the literature, Shouyu (2017) identified three main perspectives when it comes to the impacts of innovation on firm performance: first, that there is a direct outcome (that include an impact positive, non-positive or even no impact on performance), second, the perspective that suggests a moderating variable such as, for example, the international market that affects the impact that innovation can have, and finally, the last perspective sees a mediating variable like, market position, that makes the bridge between innovation and performance.

2.2.2. Innovation Types

There are distinct classifications in terms of the innovation's 'types'. Starting by the considered by many as the father of innovation, Fagerberg (2003) describes Schumpeter's distinction between five types that include new products, new production methods, new supply sources, new markets exploitation, and new ways of business organization. Nevertheless, the attention has been more on new products and new production methods.

Later, OECD/Eurostat (2005) released the *Oslo Manual 2005* that included four types of innovation: product innovation, process innovation, marketing innovation, and organisational innovation. According to the same source, they are classified as follows:

- *product innovation* occurs when the company creates a new or significantly updated good or service. In this type are included the "improvements in several technical specifications, components, and materials, software in the product, user-friendliness or other functional characteristics"(OECD/Eurostat, 2005, p. 48).

- *process innovation* results from a new or substantially improved production or method of delivery, including modifications in equipment or methods used in the productive process and/or in the software used.
- *marketing innovation* as the name suggests involves new or improved changes in marketing, which can include different product design, placement and/or promotion, or a new method behind the pricing.
- a new organisation method in the workplace, business, or external relations is designated by *organisational innovation*.

After 13 years, a new version of the manual by OECD/Eurostat (2018) was launched, where the four types were reduced to only two types. Moreover, the most recent version divides innovation into two broader concepts. First, it defines the already existing product innovation type and then, the main difference lies in the second type of innovation that is business process innovation. The business process innovation includes the "new or improved business process for one or more business functions that differ significantly from the firm's previous business processes and that has been brought into use by the firm"(OECD/Eurostat, 2018, p. 21). Now, this innovation type, encompassing the previous other three types, includes six functions of the company that goes from the production to the delivery of products and also the functions of support to the operation of the firm. Despite this new suggested typology, in applications to European Funds is still used the division into four types, so that's the one adopted in this study.

Furthermore, innovation's multidimensionality makes it a complex concept. Depending on the degree of newness, innovation can be further classified as radical or incremental (Bigliardi et al., 2011). Those two types of innovation also can be classified as new-to-market and new-to-firm innovation. A new or an improved product or service, that has not been distributed into the market before is considered a new-to-market innovation. Nonetheless, it could already be accessible in different markets. The new-to-firm innovation happens when the firm introduces a new product, service, or process but the competition already made it accessible to the market. So, the company is not bringing something new (Doran & Ryan, 2014).

Garcia and Calantone (2002) suggested that, even though it can previously exist in other industries, new-to-market innovation can be considered as a radical innovation. When it

comes to the classification as a new-to-firm innovation it can be incremental or resulting from imitation, as the product is already made by competitors (Doran & Ryan, 2014).

2.3. SMEs and Innovation

Among the innovating EU-28 SMEs, and according to European Commission (2019) in the recent *Annual Report on European SMEs 2018/2019*, there are some conclusions regarding the types of innovation followed by SMEs: nearly half of SMEs establish simultaneously a product and/or process (the more productive linked innovations) plus organisation and/or marketing innovations (the more linked to the business types of innovation); a little over a quarter conducted only product and/or process innovations; and about less than a quarter only organisation and/or marketing innovations. From 2014 to 2016, the innovation in SMEs regarding the manufacturing sector had a frequency rate higher than in the services sector in 11 different Member States. In the remaining 13 Members, which include Portugal, the frequency was higher in the services sectors, according to the same source.

The importance of innovation on small businesses management was previously mentioned (Mugharbil & Weheba, 2018), however, despite the extensive number of studies on this subject, the investigation on SMEs' innovation has a substantial variety of focuses and themes. According to Laforet (2011), regarding the elements of success to innovation, and its inputs and outputs, there are still many undiscovered and unexplored areas. Several factors should be taken into consideration and are explored below, such as the challenges they face, the opportunities they have to mitigate those challenges (namely community funds), and the internal factors that influence their adoption of innovation.

2.3.1. Challenges Faced

Moreover, when it comes to innovation there are several challenges that SMEs must overcome, like scarcity of resources, innovation processes not optimized, bad structure in internal capabilities or even lack of adequate ones (Hossain & Kauranen, 2016). Those set of issues related to innovation are also present in the *SME definition guide* by European Commission (2020c), which includes:

(1) **Market failures:** SMEs may not be able to obtain funding or invest in R&D and innovation, or they may not have the resources to meet environmental regulations. Ayyagari et al. (2017) also described the significant credit gap that SMEs face, due to unavailability of

trustworthy credit information and absence of proper collateral, where governments perform an essential role with regulations, support policies, and providing financial services directly; (2) **Structural barriers:** These barriers may include the skills and technique of management that may not be enough or adequate, the inflexibility of the labour markets, and the limited understanding when it comes to international expansion opportunities.

According to available data, from 2014 to 2016, in the EU, the percentage of large firms that performed innovation activity was 77.4% versus the 49,5% of SMEs (European Commission, 2019).

Despite all, SMEs also have some plusses such as less bureaucracy, extra flexibility in decision processes, more room to take risks, and frequently particular expertise in a specific niche (Hossain & Kauranen, 2016).

2.3.2. The Impact and Relevance of Community Funds

As previously mentioned, SMEs face market failures. Compared to large companies, they have fewer resources and less possibility to obtain financing, due to a lack of relevant credit information (Ayyagari et al., 2017), which leads to the necessity of governmental help to maximize the SMEs potential. Moreover, following Arrow (1962), a free market is expected to underinvest in R&D and innovation (when compared with the optimal value), because of the risk that it implies, which impacts the production of knowledge in society (Berrutti & Bianchi, 2020). This line of thought is usually on the basis of the innovation policy pursued by institutions.

Likewise, the European Union has several funding programmes on research and innovation, which include the Horizon 2020, the Cohesion Fund, the European Regional Development Fund (ERDF), and others, with different areas and focus. Particularly, Horizon 2020 is the largest research and innovation program conducted by the European Union and its main goal is to promote the development of science and minimize the innovation's barriers (European Commission).

Regarding its effects and impacts, there is still no evidence as the programme is just ending and the post-project performance data is yet unknown. Even though, there are already studies, such as the one by Mina et al. (2021), with conclusions on the types of companies that have most applied to this programme. Those authors found that the programme attracts

firms with high potential growth and that having patents and previous venture capital funding is strongly related to the success of the application. Besides, there is a predominance of applications from companies in the manufacturing and high-tech sectors.

2.3.3. Internal Factors and their Influence

When thinking about innovation, SMEs have to face challenges, but they also need to be aware of whether there is an impact of their characteristics and internal factors on their strategy. Although most studies on innovation are made on a posterior phase, focusing on the effects that innovation has on firm performance (Gunday et al., 2011; Sipos & Ionescu, 2015), there are some studies on which factors may seem to influence innovation on firms. Only a few like Demircioglu et al. (2019) take a deeper perspective by focusing on the different types of innovation instead of focusing on innovation as an all. Demircioglu et al. (2019) pointed out this gap in correlating factors to the different innovation types and investigated the effect of the external sources of knowledge (suppliers, clients, universities) on each type of innovation. It used a sample from 4845 American companies and found that universities are an especially important source and that, for all innovation types, companies that were younger and with more employees had on average a better level of innovation activity.

On another note, Bayarçelik et al. (2014) studied case-based strategic innovation success factors for SMEs. Their methodology included an interview with 33 SME' owners and managers in Istanbul to try to determine the most relevant factors that influence innovation and are the priority to decision-makers when considering innovation. The results were management skills, financial position, technological capability, and organisation size.

Furthermore, a report made by European Commission (2019), named *Annual Report on European SMEs 2018/2019*, presents the results of a combination of statistical analysis related to the differences in Research, Development (R&D) and Innovation performance of SMEs from the European Union, and the factors behind those differences. This report sums together three datasets[1] at different levels (micro and macro) and, according to the European Commission (2019), the analysis of those generate coherent results that highlight differences

[1] such as the Community Innovation Survey (CIS), the ECB/EC Survey on Access to Finance (SAFE), and the 2016 Innobarometer.

in key factors as sector, size, age, ownership, growth, exports and independence. Throughout the literature, other authors suggested the impact of other dimensions that are also relevant and are described next.

- *Sector of Activity*

Regarding the sector of activity, and following Malerba (2004), national institutions can impact innovation differently between sectors. According to the European Commission (2019), the companies more prone to innovate were the ones present in 'manufacturing', 'wholesale and retail trade' or in 'services' sectors. Forsman (2011) went even further and conducted an email questionnaire, with a response from 708 Finnish small companies, that found empirical evidence that there are significant variations in innovation capability and development within the different manufacturer and service subsectors.

- *Age*

The European Commission (2019) found that younger SMEs were more prone to innovation, which is also observed by other authors such as Demircioglu et al. (2019). Cucculelli (2018) went deeper and suggested that regarding product innovation, there are different likelihoods over the lifecycle of the firm: up to 18–20 years a decreasing tendency is observed, then a net rise and the maximum likelihood is reached when the company complete 30 years. After that, it is observed a decrease from 35 years onwards.

- *Size*

Addressing the previously mentioned limitations to innovation, namely in terms of financing, size seems to be an important measure, and it is one of the most explored in the literature. The conclusions from the European Commission (2019) show that micro-enterprises were less likely to innovate when compared with small and medium-sized enterprises. Nonetheless, Damanpour (1992) investigated innovation types as moderators in the relation between firm size and innovation, but despite having found a positive impact of firm size on innovation, innovation types weren't, according to the analysis, a significant moderator. Besides, this author also finds size more correlated with the implementation phase of innovation than with the initiation itself.

Moreover, there are other aspects to have in mind when thinking about size. As previously explained SMEs are classified into Micro, Small and Medium according to the number of

employees and turnover, which makes size a rich component in terms of information. Gallié and Legros (2012) used the number of employees to measure the size and the empirical results showed a significant impact of firm size on innovation (measured by the number of patents). This highlights the fact that different measures can have different impacts.

- *Competitive Scope*

The choice of the company to focus on a broader market or in a niche can also affect the innovation strategy adopted. Competing with the focus on a niche, defined as "emphasis on a particular need, or geographic, demographic or product segment" (Teplensky et al., 1993, p. 508), presents an opportunity for a firm to commercialise products and/or services to a group that has been overlooked by most competitors (Abrar et al., 2009). The effect of competition on product and process innovation was addressed by Boone (2000), that found that a rise in competitive pressure increases each firm's investments in process innovation because the focus is on efficiency, however, with that industrywide increased investment in process innovation, the investment in product innovation decreases.

- *Human capital and technologic capabilities*

Smith et al. (2005) approached the qualifications theme, where education can enhance the capacity of employees to identify opportunities or to adequately developed them and found a significant relation between the level of education of the employees and the introduction rate of innovations related to new products or services. This relevance is also highlighted regarding the top management, with Bantel and Jackson (1989) finding a relation between more educated management teams and the ones more innovative.

The previously mentioned study by Gallié and Legros (2012) quotes the study Nelson and Phelps where "education enhances the ability to receive, decode, and understand information". The same study concludes that high levels of employee training is a relevant input to innovation, and the qualifications' structure also is significant to who registers the innovation. However, in this field, the authors suggest further research since they found that executives were more likely to register patents (the proxy used to innovation), and that fact can create a wrong idea that higher qualifications lead to more innovations (even though they can even come from lower qualification employees, they normally don't register them).

On a different note, Schneider et al. (2010) concluded that the qualification of employees can drive innovation when there are highly qualified people focusing on R&D and not only on the company in general. Being technology at the origin of a big portion of new products and processes, technological capabilities are, according to the OECD/Eurostat (2018), essential to take advantage of opportunities and can, therefore, influence innovation (Bayarçelik et al., 2014). Normally, this is related to the performance of R&D in the firm, which is found by many researchers to have a positive impact on innovation (Gallié & Legros, 2012). The results from Gallié and Legros (2012, p. 11) showed that this impact is not in the same amount with a relation of "*10% increase in R&D intensity"* for a 0.5% increase on the patents number. Moreover, Medda (2020) finds R&D Intensity (R&D expenditures over total turnover) as a positive and significant factor affecting the probability to carry out product and process innovation (being the marginal effect larger to product innovation).

- *Ownership*

Regarding the company structure of ownership, it is also an explored topic in the literature with Minetti et al. (2015) finding that the concentration of the ownership affects negatively the introduction of new products. The same authors found that family firms were more likely to innovate when comparing with firms that had a financial institution as their main shareholder. These results are not confirmed by the analysis made by the European Commission (2019), which found that enterprises with ownership by public shareholders, venture capital, or business angels seemed to innovate more when compared with SMEs owned by a group of entrepreneurs or a family. The independence of the firm according to the European Commission (2019) gives mixed evidence, with one analysis finding no impact while another finds the impact to be positive.

- *Exports*

Exports are also suggested as a key factor with the European Commission (2019) finding that exporting SMEs were more likely to innovate. Although, Aghion et al. (2018) conclude that this is only beneficial when companies are initially more productive. For the less productive companies, with the dominance of external competition, the effect found was the opposite. From firm-level data relative to the People's Republic of China, one of the world's largest exporters, Lin and Tang (2013) conducted a study that goes in the same direction concluding that exports increase a firm's innovative activity.

Moreover, OECD/Eurostat (2018, p. 105) in the referred *Oslo Manual 2018* suggests a large number of business capabilities - which includes "knowledge, competencies, and resources" that the firm owns - that are important in the innovation process. According to the same source, they are essential to understand the drivers and outcomes that differentiates the companies from enrolling on innovation or not, and the innovation types conducted. Besides, this publication highlights the key indicators that should be collected when analysing innovation, which include the number of employees, the turnover, the structure of ownership, the division of sales by market, the percentage of sales exported, the focus of the company strategy (cost vs quality), and the level of design capability. A resume of the main contributions to each factor previously described is presented in Table 2.

Table 2: Factors that impact innovation on SMEs and were found in the literature

Characteristics	Conclusions	Authors
Sector economic activity	'Manufacturing', 'wholesale and retail trade' or 'services' sectors have SMEs more likely to innovate.	European Commission (2019)
	National institutions have different impacts on innovation from different sectors.	Malerba (2004)
	Differences in innovation capability and development within the manufacturer and service sectors are significant.	Forsman (2011)
Age	Younger SMEs were more prone to innovation.	Demircioglu et al. (2019); European Commission (2019)
	There are different likelihoods of product innovation over the lifecycle of the firm.	Cucculelli (2018)
Size	Micro SMEs were less likely to innovate when compared with small and medium-sized SMEs.	European Commission (2019)
	Firm size is an important determinant of the amount of R&D conducted by firms.	Choi and Lee (2018)
	Size is one of the most important criteria for decision-makers.	Bayarçelik et al. (2014)
	Firm size has a significant impact on innovation.	Gallié and Legros (2012)
Competitive Scope	A rise in competitive pressure increases investments in process innovation but decreases product innovation's investment.	Boone (2000)
Human Capital	Management skills are a relevant factor in innovation.	Bayarçelik et al. (2014); Bantel and Jackson (1989)
	The qualification of employees can influence innovation.	Gallié and Legros (2012); Smith et al. (2005)
Ownership	Enterprises with ownership by public shareholders, venture capital, or business angels seemed to innovate more when compared with SMEs owned by a group of entrepreneurs or a family.	European Commission (2019)
	The concentration of ownership negatively affects the introduction of new products.	Minetti et al. (2015)
Exports	Exporting SMEs were more likely to innovate.	European Commission (2019)
	Positive effect on firms that were initially more productive. For the less productive companies, the effect is the opposite.	Aghion et al. (2018)
	Both exports and productivity impact positively innovation.	Lin and Tang (2013)
Technological Capabilities	The intensity of R&D affects positively innovation but not in the same amount.	Gallié and Legros (2012); Medda (2020)

Source: Author gatherings from literature.

2.4. Research Framework

Having in mind all the factors that were found to impact innovation, this study aims to go deeper by filling the literature gap on understanding whether those factors are related to the nature of innovation, in the case of SMEs applying to European Funds. This division in innovation types is crucial due to their heterogeneity of attributes and adoption' processes and, therefore, defended by several researchers.

For example, Kimberly and Evanisko (1981, p. 692) state that technological and administrative innovations are mostly constrained by different structures of decision so "there is no reason to believe a priori that the factors explaining innovation adoption in the two cases will be identical". Having in mind the different impact of innovation types on performance analysed by Sipos and Ionescu (2015) and others, this study becomes relevant and it aims to contribute to the conscious management of innovation and investments by identifying if the different inputs, particularly firm characteristics, affect the types of innovation: product, process, organisational and marketing.

The reasoning why it was included the adoption of both product and process types as a dependent variable was based on existing literature that founds a strong connection between them. Damanpour and Gopalakrishnan (2001) found a positive association in organisational performance at a firm level and also a synchronous pattern between product and process innovation, grounding the previous evidence found by other authors.

This study will test the following hypotheses, summarized in Figure 1:

H1: Firm characteristics influence the adoption of Product Innovation.
H2: Firm characteristics influence the adoption of Process Innovation.
H3: Firm characteristics influence the adoption of Both Innovation Types.
H4: Firm characteristics influence the adoption of Organisational Innovation.
H5: Firm characteristics influence the adoption of Marketing Innovation.

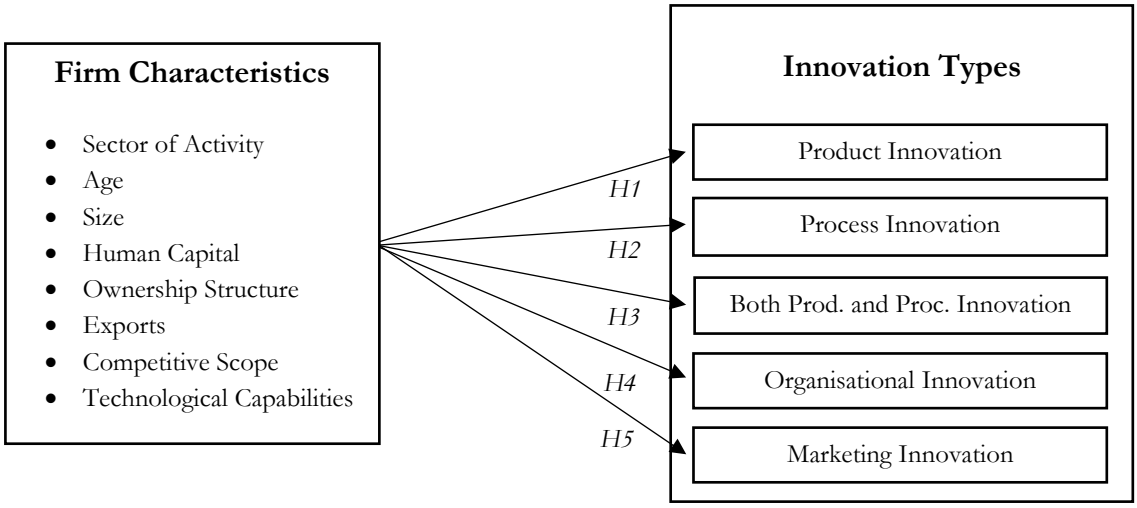

Figure 1: Research framework and hypotheses

Source: Author creation.

3. Methodology

The methodology of this study consists of two different but complementary approaches: cluster analysis and the application of three binary logistic regression models. Both were conducted using a self-reported and unique dataset, with the main goal to understand whether the characteristics of companies influence the type of innovation they undertake.

In the next subchapters, the data and sample are described, followed by the explanation of the several variables and the way they were gathered. Then, the cluster analysis is conducted. This analysis was chosen because it is widely used when it comes to segment companies in the innovation context although mostly analysing the geographic effect (Portugal Ferreira et al., 2012). In the context of this study, cluster analysis is used to identify and analyse the different homogeneous groups of companies' types of innovation.

Besides the identification of homogeneous groups, this study also makes a quantitative analysis of the impact of different characteristics on the type of innovation conducted. The quantitative analysis consists of the application of a binary logistic model with three different dependent variables. Similar studies were found in the literature, for example, Medda (2020) studied the impact of R&D investments on product or process innovation. The author used probit regressions with similar dummy dependent variables indicating whether firms have carried out process or product innovation in the past three years. On a different note, Mahmutaj and Krasniqi (2020) studied the impact that factors, such as the type of innovation, have on sales growth. They used dichotomous variables and applied a logistic regression model.

As states Cakmakyapan and Goktas (2013, p. 1) referring to probit and logit regressions "when the dependent variable is binary, both models may be used for the estimation of the functional relationship between dependent and independent variables". That said, after testing that there were no significant differences between the two, the results from the logistic model were analysed to understand if there is any significant relationship between the variables.

3.1. Data and Sample

The target population of this study is the SMEs that apply to European Funds with projects of product and process innovation. The application process for these funds/programs requires a detailed plan of action, which makes many companies seek help from consulting companies. In the context of a Curricular Internship, a sample constituted by clients of a consulting company was gathered for this study. This consulting company supports SMEs in the application process for tax breaks and community funds, which are financial instruments available to companies to develop or expand their businesses

Firstly for this study's purpose, I considered the European Union (2003) definition of SMEs as well as the OECD/Eurostat (2005) division on four innovation types, as the data analysed in the sample refers to European SMEs.

Moreover, this sample is classified as a non-random sample also known as the convenience sample and is especially suited to this study as (1) the consulting company works with several Portuguese SMEs, with different characteristics and sectors; (2) Portugal was classified as a strong innovator in the *European Innovation Scoreboard of 2020*, and a leader when only considered SMEs, which means that it is above the average of innovation performance in the EU (European Commission, 2020a), and (3) it is one of the countries with a higher Share of EU Cohesion Policy to public investment on 2015-2017 (European Commission, 2020b).

The data was extracted from the consulting company files during January and February 2021, ensuring the anonymity of all clients. From the files, 1385 folders were consulted (each corresponding to a client or potential client). There was a fair number of projects with an extensive description of the company itself, the project that it is applying to, and all the financial information from recent years. For this study's purpose, the project's application to the incentive programme is used as a proxy of the companies' innovation.

In this study, only clients that applied to *SI Inovação Produtiva* integrated in the Portugal 2020[2] were considered, due to the complete application when comparing to other Incentive Programmes. This programme is a line of support to the production system, stimulating the innovative investment of any company of any legal form.

[2] Portuguese Horizon 2020.

According to IAPMEI (2021), this program intends to ensure business innovation through incentives to conduct product or process innovation. These types of innovation are not necessarily disruptive as they can be new only to the company, new to the national market or new to the international market.

Furthermore, this specific incentive programme only considers eligible investments in innovation that result in the production of tradable and internationalizable goods and services and with a high level of national incorporation. According to the IAPMEI (2021), the projects applying must belong to at least one of the following types:

i) *The creation of a new establishment.*

ii) *The increasing of the capacity of an existing establishment.*

iii) *The diversification of an establishment's production into products not previously produced in the establishment.*

iv) *The fundamental change in the overall production process of an existing establishment.*

There are some aspects to consider that affect the characteristics present in the sample. To be eligible to apply, companies must meet the following requirements:

- Have a balanced economic and financial situation and the situation settled with entities such as the AT, SS and FEEI.
- Have the technical, physical, and financial means and the necessary human resources to start the project.

Additionally, the eligible expenses of the application must be between seventy-five thousand euros and twenty-five million euros. When it comes to the chosen time frame, the period of applications from 2015 to 2020 was selected, since it allows for an extended sample and ensures an updated analysis. Taking these criteria into account, 123 observations were collected (i.e., 123 different application forms), from where the variables were registered in an excel form. From this data, the following should be considered:

a) The study only includes companies that were already established in the market and therefore had at least 3 years of activity. This criterion is especially suited to this study as it intends to analyse whether the characteristics and evolution of the company are statistically related to the type of innovation pursued.

b) Nine observations are from companies that had more than one application with different projects submitted in different years. As the characteristics are different (the same company in different time frames), they were considered as different observations.
c) The classification of the variables 'competitive scope' and 'types of innovation' in the application is jointly decided by the consultant involved in the project together with the client, meaning that it is the result of their subjective interpretation.
d) The data of the remaining variables (also collected from the application) is based on documentation that companies make available to the consultant for the preparation of the application. Therefore, these are associated with a lower rate of subjectivity.

Additionally, the data is self-reported, so the information is gathered directly from the applications. Also, in this study, the applications are used as a proxy for the type of innovation developed by the company, which may not fully represent the innovative activity of companies.

3.2. Independent Variables

The independent variables are described below in Table 3, together with some relevant aspects of the process of information gathering.

Table 3: Independent variables

Characteristics	Notes on data and variables	Independent Variables
Sector economic activity (CAE[3])	In the application form, there is a field with the CAEs of the company and their percentages in the company's turnover, both pre and post-project. It was considered the CAE with the largest percentage at the date of the application. Data only had 8 different sections represented. From these 8 sections, only 12 out of 123 observations had sections distinct from the section C and G. To codify this variable, it was created two dummy variables that correspond to the 2 main sections, the rest of the observations being differentiated when the following variables are both equal to 0 (so the company does not belong to the most common sectors).	"**Manufacturing**": takes the value 1 if a company operates in the Manufacturing Industries and 0 otherwise.
		"**Trading**": takes the value 1 if a company operates in the wholesale and retail trade or repair of motor vehicles and motorcycles, and 0 otherwise.
Age	Firm age was collected having in mind the activity start year.	**"Age":** Numeric variable that expresses the firms' age at the application date, calculated by [Year of the application – Start Year of the activity].
Size	Categorical variable with three possibilities (micro, small and medium), codified into two dummy variables. Besides the classification that was associated with 3 different factors: Headcount: annual work unit (AWU); Annual turnover or Annual balance sheet total, data about the turnover was collected separately as it can isolate the effect of sales on the Innovation Type (ignoring the number of employees and the balance sheet).	**"SizeMicro":** 1 if the company is classified as micro; 0 if otherwise.
		"SizeMedium": 1 if the company is classified as medium; 0 if otherwise.
		"LogTurnover": Numeric variable that represents the logarithm[4] turnover of the company in the pre-project year.

[3] Classification of Portuguese Economic Activities by Industry. It is constituted by 5 digits and the first two (named 'division') correspond to a "section" represented by a letter (from A to U). This study uses the classification of 2007.

[4] The logarithm was applied to provide a solution to an issue with the visualization of the data and identification of patterns caused by the skew of the visualization towards large values in the dataset. By applying the logarithm to all values of turnover instead of a standard linear scale, the values are based on order of magnitude.

Competitive Scope	Defined by the consultant with the client, involving a more subjective perspective of the company.	**"CompetitiveScope":** 1 if the company operates on a niche[5], 0 if otherwise.
Human Capital	Human capital considers both employees' and managers' qualifications. It is measured by the average level of qualifications[6], i.e., work posts in the pre and post-project years, divided by level of qualification and functional area. In the case of employees, we calculated a mean of the values and did not consider the individuals that belong to the management team.	**"EmployeesQ":** Numeric variable. Mean of qualifications of the employees. **"ManagersQ":** Regarding managers, the study considers the average qualification of individuals belonging to the area of Management/Administration. In 13 applications, as there was no one allocated to this functional area, we assumed the manager as the person with a higher level of qualification.
Ownership	Ownership is defined by the description of the shareholder's type.	**"TypeShareholders":** Dummy variable that takes the value 0 when the company only has individual shareholders and the value 1 when the company is owned (even in a small percentage) by another company.
Exports	Assesses whether the company directly exports to one or more countries.	**"Exports":** It´s a binary variable. 0 if the company does not export; 1 if the company exports.
Technological Capabilities	Measured by the investment in R&D in the years before the project.	**"RDIntensity":** Numeric variable that was calculated by dividing the R&D expenditures in the pre-project year by the turnover in that same year.

Source: Author creation.

[5]A niche market strategy is an "emphasis on a particular need, or geographic, demographic or product segment" Teplensky, J. D., Kimberly, J. R., Hillman, A. L., & Schwartz, J. S. (1993). Scope, timing and strategic adjustment in emerging markets: Manufacturer strategies and the case of MRI. *Strategic Management Journal, 14*(7), 505-527. .

[6]See Annex 1.

3.3. Dependent Variables

The dependent variables are codified in five different dummies explained in Table 4:

Table 4: Dependent variables

Dependent Variable	Explanation
"ProductInnovation"	1 if the project includes product innovation; 0 if otherwise.
"ProcessInnovation"	1 if the project includes process innovation; 0 if otherwise.
"BothInnovation"	1 if the project includes both product and process innovation; 0 if otherwise.
"OrganisInnovation"	1 if the project includes organisational innovation; 0 if otherwise.
"MktInnovation"	1 if the project includes marketing innovation; 0 if otherwise.

Source: Author creation.

To make a complete characterization of the type of innovation, two additional categorical variables were collected, related to its degree of newness, as shown in Table 5. The degree of newness related to marketing and organisational innovation types wasn't collected due to the high subjectivity involved.

Table 5: Additional variables related to the innovation newness

Variable	Explanation
"ProdInnovNew"	If the product innovation is: only new to the company or does not exist = 1; new to the Nacional market =2; new to the international market =3.
"ProcInnovNew"	If the innovation is: only new to the company or does not exist = 1; new to the Nacional market =2; new to the international market =3.

Source: Author creation.

3.4. Descriptive Analysis of the Sample

The goal of this study is to understand whether there is a relationship between companies' characteristics and the type(s) of innovation they perform, in the case of SME's applying to European Funds. In this case, it was used applications to an incentive programme as a proxy of the types of innovation performed by companies. To take any conclusions is important to start with the descriptive analysis of the sample.

Concerning the characteristics of the application, most companies in the sample submitted their project in 2016 (Table 6). For the years 2018 and 2019, there were a lower number of applications available. This decrease could have two reasons: lower incentives or programmes in that year or a lower interest/performance of the consulting company in this incentive programme. After analysing the report of the *Status Incentive Systems Portugal 2020* made by COMPETE (2021) for all months during the years present in the sample, it could be concluded that this decrease is related to the sample itself and with the activity of the consulting company.

Table 6: Distribution of the application year

Application Year	
Year	*Sample (%)*
2015	24.4
2016	29.3
2017	11.4
2018	8.1
2019	8.1
2020	18.7

Source: Author creation.

As previously mentioned, for this study, I only considered projects that applied to *SI Inovação Produtiva*, but projects can apply to more than one incentive programme being the case for many companies from the sample (Table 7).

Table 7 shows the combinations of incentive programmes to which the projects present in this sample applied. The Incentive Programmes are normally linked with the innovation type of the project, *SI Internacionalização* is deeply connected with investments in Marketing Innovation and *SI Qualificação* with investments in Organisational Innovation. Projects that

applied to more than one incentive are normally extensive investments in various aspects of the business, but more than 60% of the sample only applied to one incentive (with the same project).

Table 7: Distribution of the incentive types

Incentive Type	
Incentive	*Sample (%)*
INOV	63.4
INOV+INT	26.0
INOV+INT+QUAL	7.3
INOV+QUAL	3.3

Source: Author creation.

Moreover, from the 123 companies analysed, most are companies classified by IAPMEI as small-sized (Table 8) and operate mainly in the manufacturing sector followed by the trading sector (Table 9).

Table 8: Distribution of size classification

Size	
Classification	*Sample (%)*
Micro	21.1
Small	55.6
Medium	23.3

Source: Author creation.

Table 9: Distribution of sector of activity

Sector of activity	
Classification	*Sample (%)*
Manufacturing	80.5
Trading	9.8
Other	9.7

Source: Author creation.

The sample shows a great majority of companies that directly export to at least one market (82.1%), and, in terms of scope, most companies are classified in the application as companies with a broader market (versus a niche approach).

When it comes to ownership, only a few showed the presence of other companies in their equity. Furthermore, the average qualification of managers is approximately one level[7] higher than the mean qualification of the employees. So, for example, when the qualification level of the manager is equal to 3, that represents the Secondary education aimed at pursuing higher education, the average of qualifications of the employees is the 3rd cycle of basic education, obtained in regular education or through double certification programmes (2nd level).

Table 10 shows some statistical indicators of the independent variables.

Table 10: Statistical indicators of the explanatory variables

	Minimum	Maximum	Mean	Standard deviation
Firm Age	3	54	20.09	12.489
LogTurnover	4.8189	7.2830	6.254661	.4811106
ManagersQ	1	8	3.90	2.060
EmployeesQ	1	8	2.93	1.193
RDIntensity	.0000	.1519	.008004	.0197563
TypeShareholder	0	1	.25	.436
Exports	0	1	.82	.385
CompetitiveScope	0	1	.40	.492

Source: Author creation.

The objective was to include the marketing and organisational types of innovation in this study. But after the data collection and analysis, I concluded that approximately 92% of the companies in this sample performed those innovation types (either one or even both).

This is explained by the evaluation process that attributes extra points to companies that perform a combination of innovation types, incentivizing companies to focus not only on the productive part, such as the products or processes. That said, it wasn't possible to

[7] See Annex 1.

differentiate companies that performed these innovation types, and, therefore, the study of those could not lead to any conclusion rather than that they are reportedly widely adopted. Having this in mind, Table 11 shows that more than 90% of the sample performed 3 or more innovation types.

Table 11: Different innovation types present on the application

Innovation Types	
How many different innovation types?	*Sample (%)*
1	0.02
2	0.06
3	0.37
4	0.55

Source: Author creation.

Furthermore, the analysis was focused on the other three variables, product, process and both product and process innovation.

4. Results

This chapter contains the results of two approaches used in this study: cluster analysis and binary logistic regressions. First, the results are presented and later in the last subchapter, the results are analysed and compared with existing literature.

4.1. Cluster Analysis of Innovation Types

To more fully characterize the type of innovation that companies in the sample carried out, a cluster analysis was conducted using the variables of product and process innovation and their respective novelty (divided into 3 categories: 1 if not new or new only for the company, 2 if it was new for the domestic market and 3 new for the international market). Once again it is important to refer that it was used self-reported data, so the companies together with the consulting firm, identified these categories.

A two-step algorithm was chosen due to its advantages as an explanatory tool that was, according to IBM (developer of the software SPSS used), "designed to reveal natural groupings (or clusters) within a dataset that would otherwise not be apparent". The results led to five clusters, with a well successful quality of cohesion and separation[8].

Figure 2 shows the correspondent sizes of the five homogeneous groups of companies that performed similar kinds of innovation (or at least reportedly did so).

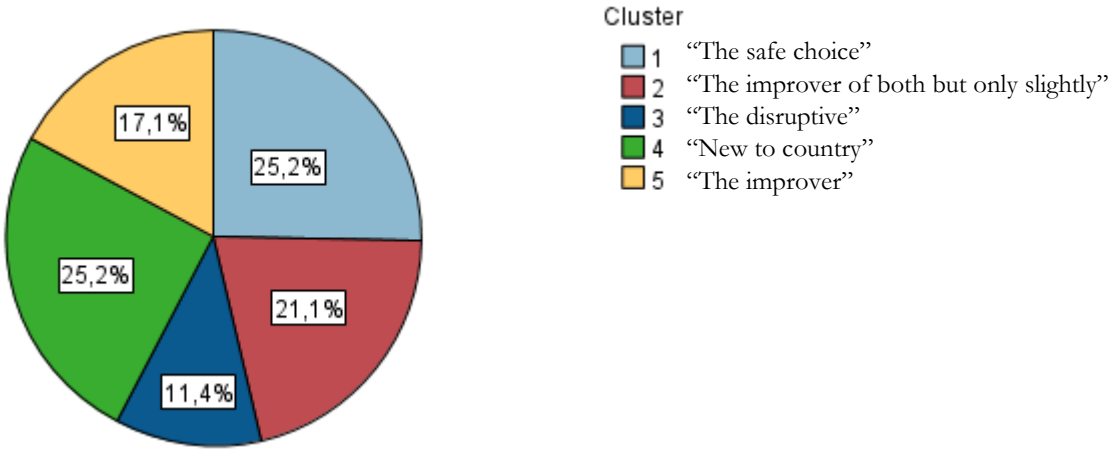

Figure 2: Clusters' Size

[8] The most important predictors were the Product and Process Innovation (both with 1.0) followed by Product Innovation Newness with 0.76 and Process Innovation Newness with 0.71.

The first cluster, named "safe choice", represents companies that only performed process innovation (without performing product innovation). In this cluster, most companies implemented process innovation, which was only new to the company (already existed in the National market).

The second cluster "improve both but only slightly" incorporates companies with both product and process innovation, but both were only new to the company. This is the case of 21.1% of the sample, showing many candidates that are not bringing differentiated innovations, not even to the national market.

The third cluster, named "the disruptive", focus on the companies that only performed product innovation and concludes that in those, most of the product innovations are new to the international market.

The last two clusters include companies that, although investing in both innovation types, differentiate themselves by the level of the newness of those innovations. The fourth cluster, named "new to country", involved mostly innovations new to the national market (both product and process), and the fifth ("the improver") is characterized by product innovation new at a national level, but process innovation based on improvements/changes only new to the company.

Summarizing all the conclusions is Figure 3 below. Each colour represents a cluster, and the size of the circles corresponds to a 3-level scale, where the smallest represents less than 10 companies, the medium between 10 and 20 companies and the largest more than 20 companies.

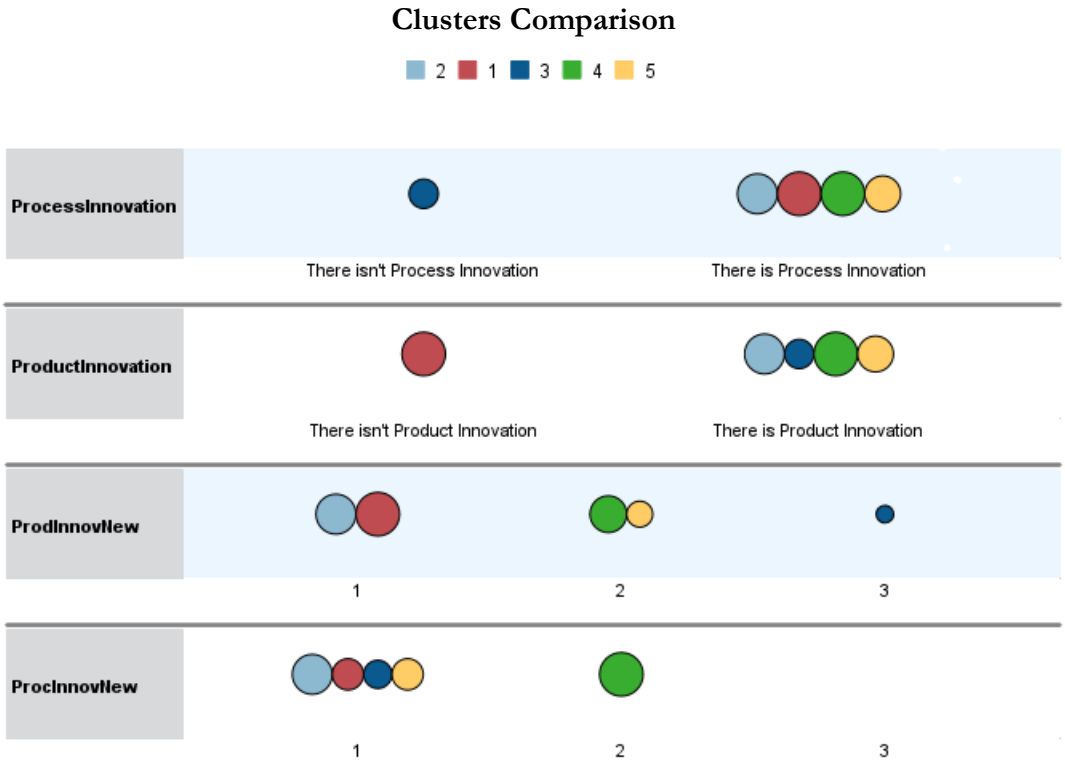

Figure 3: Cluster comparison

Source: Retrieved from SPSS.

4.2. Estimation and Diagnostic Tests

The estimation was done recurring to a Logistic Binary Regression using the IBM SPSS Software (version 27). Three different regression models were used to predict three dichotomous variables of innovation types. The dichotomous variables are product innovation, process innovation and both innovation types, coding 1 if there is an investment in that innovation type(s), and 0 if there is not. The independent variables comprise firm characteristics found in the literature. The discussion of the econometric logit model through SPSS is used to investigate which of the factors have a significant relation with innovation type.

Before conducting the models, the assumptions for the Logistic Binary Regression were tested, especially testing for multicollinearity of the independent variables. The Variance Inflation Factors (VIF) coefficients were well below the 10-cut-off recommended, which show no evidence of high multicollinearity between the independent variables.

4.3. Logistic Binary Regression

The best logistic regression models for each dependent variable are presented next. The conclusions from the results are interpreted in the discussion of the results subsection.

4.3.1. Product Innovation

Although the model is not significant when α=.5, the association is statistically significant for α=.10 (Table 12). So only for that significance, the null hypotheses (*H0: "Firm characteristics do not impact product innovation*") can be rejected, and it can be concluded that Firm Characteristics are related to product innovation.

In terms of individual significance, only Exports is statistically significant at the level of significance of 5% (Table 13). This means exports show a positive impact on the pursuit of product innovation.

The results about Competitive Scope offer some doubts, as it is not significant at 5%, but it can be considered significant when considering a unilateral test with 10% significance.

Thus, empirical evidence indicates that a higher level of exports and competitive scope are important factors in determining product innovation.

Table 12: Omnibus tests of model coefficients (product innovation)

	Chi-square	df	Sig
Model	8.657	4	.070

Source: Author creation.

Table 13: Variables in the equation (product innovation)

	B	S.E.	Wald	df	Sig.	Exp(B)
EmployeesQ	.239	0.209	1.310	1	.252	1.270
Trading	1.221	1.083	1.271	1	.260	3.389
CompetitiveScope	.722	.471	2.350	1	.125	2.058
Exports	1.129	.545	4.294	1	.038	3.093
Constant	-.844	.876	.928	1	.335	.430

Source: Author creation.

4.3.2. Process Innovation

The proposed model is globally significant (Table 14). The statistical hypothesis, *H0: "Firm characteristics don't impact Product Innovation"*, is rejected (at α=.05, being P=.047), which leads to the confirmation of the relevance of the firm characteristics in the explanation of the adoption of process innovation.

Furthermore, when it comes to the individual variables (Table 15), statistical analysis reveals four variables as statistically significant. The Manufacturing and Age variables show individual significance at the 5% level. Both impacts with a positive signal, so older age is associated with the adoption of process innovation, and manufacturing companies tend to show a higher probability to perform this type of innovation.

Moreover, size variables such as Log turnover and SizeMicro are significant considering the level of significance of 10%.

As shown, the Logturnover coefficient is negative what suggests that an increase in the turnover of the company leads to a decreased probability of performing process innovation. Nevertheless, SizeMicro that was codified as 1 to micro-companies and 0 otherwise, also shows a negative association with process innovation. That said, the size variables give results in opposite directions, which leads to believe that the intermediate size (small companies) have a higher probability to perform this innovation type.

Thus, empirical evidence indicates that being a manufacturing and older company are important factors in determining process innovation. The size (and their turnover isolated) can also affect the adoption of this innovation type.

Table 14: Omnibus tests of model coefficients (process innovation)

	Chi-square	df	Sig
Model	17.1122	9	.047

Source: Author creation.

Table 15: Variables in the equation (process innovation)

	B	S.E.	Wald	df	Sig.	Exp(B)
Age	.070	.033	4.446	1	.035	1.072
ManagersQ	.163	.162	1.018	1	.313	1.177
RDIntensity	19.012	22.459	.717	1	.397	180690672.673
LogTurnover	-1.848	.978	3.571	1	.059	.157
Manufacturing	1.836	.709	6.709	1	.010	6.270
SizeMicro	-1.648	.989	2.775	1	.096	.193
CompetitiveScope	.684	.711	.925	1	.336	1.982
Exports	-1.128	1.157	.951	1	.329	.324
TypeShareholder	.833	.926	.809	1	.368	2.300
Constant	11.349	6.111	3.449	1	.063	84881.253

Source: Author creation.

4.3.3. Both Product and Process Innovation

The global model does not show significance (Table 16), so the null hypotheses that the firm characteristics does not impact innovation types cannot be rejected. In other words, there is insufficient evidence to conclude that this model is an improvement to the null model, where the characteristics are not considered. But with the p-value close to 10%, and since there are individually significant variables at 10% (Table 17), the analysis was proceeded, although with some caution as to definitive conclusions.

That said, some notes can be suggested with both Manufacturing and Competitive Scope variables showing significance at α=.10.

The variable MangersQ is significant in a 10% unilateral test. This is an acceptable possibility, given the requirement for the sign of the coefficient (in other words, that if it affects, the impact is positive). Since it only admits the possibility of being positive, at the level of significance of 10%, it focuses only on the right side of the distribution (so the test is one-sided).

In conclusion, having in mind the previous reservations, empirical evidence suggests that being a Manufacturing company and focusing on a niche (competitive scope) are factors that can impact the adoption of both product and process innovation.

The average qualifications of the management team also show signs that can affect positively the adoption of both innovation types since it is significant in a unilateral test at 10%. According to what was found in the literature, require the coefficient sign to be positive is an acceptable possibility so at that level the significance (10%) should be concentrated only on the right side of the distribution (therefore the test is unilateral).

Table 16: Omnibus tests of model coefficients (both innovation types)

	Chi-square	df	Sig
Model	10.334	6	.111

Source: Author creation.

Table 17: Variables in the equation (both innovation types)

	B	S.E.	Wald	df	Sig.	Exp(B)
Manufacturing	1.275	0.705	3.272	1	.070	3.577
Trading	1.158	0.915	1.600	1	.206	3.182
ManagersQ	0.150	0.101	2.212	1	.137	1.162
RDIntensity	15.202	12.057	1.590	1	.207	3998934.802
CompetitiveScope	0.723	0.427	2.862	1	.091	2.061
Age	0.021	0.017	1.466	1	.226	1.021
Constant	-1.966	0.945	4.326	1	.038	.140

Source: Author creation.

4.4. Discussion of Results

After the descriptive analysis and the application of the regression models, different conclusions can be inferred from the sample.

When it comes to technical innovations, Damanpour and Gopalakrishnan (2001) suggest that the adoption rate of product innovation tends to be higher than the adoption of process innovation because "product innovations are more observable and are perceived to be relatively more advantageous than process innovations" (Damanpour & Gopalakrishnan, 2001, p. 4). According to Marzi et al. (2017), process innovations were also much less addressed in the literature, which tend to focus on product innovation. However, contrary to what was found in the literature (Tavassoli & Karlsson, 2015), process innovation was

more frequent in the sample than product innovation. Looking at this fact and having in mind the framework of incentive systems, it is possible to connect with the previous cluster analysis.

From all the clusters, the one that only performed process innovation (therefore product innovation = 0) had predominantly innovations only new to the company. This is the opposite of what the cluster of only product innovation shows, where on the degree of newness the majority was allegedly new to the international market (once again we are in the presence of self-reported data). This leads to believe that the objective of the managing entity, IAPMEI (2021) by stating that projects of investment in mere expansion and modernization are not eligible, is not fulfilled. Companies applying to these funds seem to be slightly improving those processes with incentives that do not necessarily lead to an innovative outcome. This also brings to the discussion the definition previously mentioned of radical or incremental innovation. In the analysed sample, if were only considered innovations that were new to the market (national or international) only 47.2% of the product innovations and 42.3% of process innovations were considered.

Concerning the three innovation types analysed (product, process, and the combination of both), there was only strong statistical evidence that firms' characteristics can impact the adoption of process innovation. Manufacturing companies and/or older companies showed an increased probability to adopt this innovation type in applications to the incentive program *Inovação Produtiva*. Also, with some reservations, the variables of size showed significance (at 10% level), which allow some discussion on the possible effects on process innovation.

Moreover, as discussed in the previous subchapters, Demircioglu et al. (2019) and European Commission (2019) found that younger firms were more prone to innovation. Nonetheless, Medda (2020) finds no significant effect of age for process innovation. This is not validated by this study, which for process innovation finds a statistically significant, but positive effect of age. In other words, older companies were more prone to conduct process innovation. A plausible justification is that, although younger firms were more likely to innovate, the oldest ones seemed to have a higher probability when it comes to process innovation.

Cohen and Klepper (1996) studied how companies allocated their resources to product and process innovation, having concluded that the size impacts positively the return of

innovation and that this relationship is stronger when comparing process innovation with product innovation. This result is expected to lead larger firms to invest more in improving processes than smaller companies and can justify part of the results found in this study, where SizeMicro negatively influenced the probability of performing process innovation. Other studies also reported this effect and found that, on average, small companies spend a much higher proportion of their R&D investments on new products than on new processes (Fritsch & Meschede, 2001). Nevertheless, the logarithm of the turnover showed the opposite effect to the literature. The difference can be explained with one of two factors: (A) the variable SizeMicro has into account other aspects, such as the number of employees, which can create the difference in the results; (2) being more than half of the sample constituted by small companies, the "intermediate" size can be the one with higher probability to perform process innovation.

Furthermore, some variables on the other two models showed significance. Although the results are not statistically strong, they can give some insights into which characteristics of the companies applying to European Funds can impact the probability of the type of innovation adopted.

When it comes to product innovation, the fact that the company exported seemed to impact positively this innovation type. This is supported by the literature that finds that exporting SMEs are more likely to innovate (European Commission, 2019) and that exports impact positively innovation (Lin & Tang, 2013).

Despite this, the majority of the literature tends to focus on the positive impact that innovation has on export intensity (Pla-Barber & Alegre, 2007). Those conclusions can also lead to speculation about other possible relationships. For example, small size has been considered by several authors as an export barrier (Mittelstaedt et al., 2003; Verwaal & Donkers, 2002). If, as our results show, exports have a positive impact on product innovation and following the literature, size impacts positively exports, it can be suggested that size can also impact product innovation. Nevertheless, this connection is not validated by our sample, and it is also argued by other authors that found that is not the size that impacts exports, but the consistency between the resources and the internationalisation strategy (Calof, 1993).

Meanwhile, Cassiman and Martinez-Ros (2007) also state that product innovation is a significant driver for exports propensity, however the same does not happen with process

innovation alone (Becker & Egger, 2013). This can justify the previous effect where companies in the studied sample that exported seemed to have more probability of performing product innovation, but that link was not significant in the process innovation model. Van Beveren and Vandenbussche (2010) approaches the simultaneity of the effect of innovation and exports and finds that firms that anticipate entering the export market are more likely to invest in innovation activities. This can explain that the exports can "impact" product innovation, in a sense that companies see innovation as necessary to keep up with the international markets and not necessarily only the other way around. So, in other words, the desire to keep exporting drives them to innovate and invest in product development to differentiate and/or to meet consumers requirements.

Furthermore, the variable of both product and process innovation was tested based on the large literature about the dynamic of those types of innovation, where the implementation of a new product can imply a new process, and a new process can lead to a new/improved product (Fritsch & Meschede, 2001). With due reservations, some aspects can be highlighted: (1) manufacturing sector showed a positive impact on the probability of adopting both innovation types; (2) Competitive Scope also showed significance (at 10%), which means that companies that operate on a niche were more likely to conduct both innovation types when applying to European Funds. Boone (2000) defended that with higher competition pressure (broader market) the general industry investment in process innovation to increase efficiency harms the investment in product innovation. This can be the reasoning behind the fact that companies competing on a niche that have fewer competitors have more probability of invest in both innovation types simultaneously or even on product innovation. They are not only worried about efficiency, but they also want to respond to the unique needs of their customers.

Moreover, the variable manufacturing was highlighted in the models of process innovation and both innovation types. This is in accord with the findings of the European Commission (2019), which identifies this sector as being one of the most innovative ones. Moreover, by considering all incentives programmes present on the SI 2020, according to COMPETE (2021) in the *December 2020 Report*, the manufacturing sector applied to more than 22 million euros of investment out of the total 34 million (from all sectors).

The last conclusion worth of focus was the large adoption of types of innovation such as organisational and marketing by companies applying to the incentive programme studied *(SI Inovação Produtiva*), leading the quantitative analysis to focus solely on the other two types (and their combination). This preliminary result led me to believe that most companies include organisational and marketing innovation types to get a better chance of having the project approved. Furthermore, as these types of innovation were common to almost all the applications in the data set, they could not be used to further analyse potential correlations between the characteristics of the companies and the types of innovation. Once again, this study uses self-reported data, which brings the advantage of results unbiased from the author's point of view, but at the same time, is dependent on the rigour of the information provided by the companies when applying. So, this result can be based on one out of two possibilities: (1) the incentive systems are effective in promoting investment in the several areas of the company or (2) companies take advantage of the criterion and apply with innovation types that don't correspond to real innovations.

Despite this, the reasoning for those incentives to value the adoption of a combination of innovation types can be based on the belief of, as Damanpour and Evan (1984) stated, the more effective way of firms preserve and/or improve their level of performance is achieved with a balanced rate of adoption of administrative and technical innovations (when comparing with implementing them alone). That said, this study shows pieces of evidence that the companies applying to European Funds incorporate this strategy and are encouraged to have this into account when they think and develop their projects.

5. Conclusion

Most of the existing literature focuses on the impacts that types of innovation have on company outcomes (for example the level of performance (Gunday et al., 2011; Sipos & Ionescu, 2015)). Likewise, the literature tries to categorize innovations; however, as Damanpour (2010, p. 13) states, "innovation research should also move beyond classifications and examine environmental and organisational conditions that determine the synergetic generation or adoption of innovation types".

The present study contributes to fill a literature gap by investigating whether some firms' characteristics impact the type of innovation conducted (even if it is a non-linear relationship), in the specific case of SMEs applying to European Funds. The factors tested such as the sector of activity; age; size; human capital; ownership structure; exports; competitive scope and technological capabilities were gathered from the existing literature, that identified significant impacts of those on the general adoption of innovation.

When it comes to the results, from the three binary logistic regression models conducted (product innovation, process innovation and both product and process innovation), process innovation was the one with the strongest statistic model results, having a significant relationship with older companies and the ones operating in the manufacturing sector. In other words, these factors result in a higher probability to adopt this innovation type. Variables of size also seemed to impact the likelihood of companies performing process innovations, although with opposite directions. Being a micro company negatively affects the probability of performing process innovation, but having a higher turnover also suggested a negative impact on this probability. This led to the belief that small companies (the intermediate size) are the ones with the highest probability to perform process innovation among all SMEs.

On top of that, the company exports showed a greater impact on product innovation than on process innovation, in line with previous research on the subject (Cassiman & Martinez-Ros, 2007). With due reservations, although the model was not statistically significant, the adoption of both innovation types was suggested as more probable on companies that focus on a niche and once more belonged to the manufacturing sector. This confirms some evidence found in the literature that shows that competing in a broader market incentivizes the investment in efficiency, normally thought process innovation, decreasing the investment

in product innovation (Boone, 2000). That said, companies that perform in markets with less competition are more probable to divide the investment in both efficiency and differentiation through investment in new or improved products.

Although the sample used is made out of projects from Portuguese companies, according to the OCDE (2019), SMEs present patterns that are similar throughout the OECD countries that have been stable with time. That said, this study highlighted the relationship of certain factors to the types of innovation pursued by SMEs that applied to European Funds.

Furthermore, this study also allowed a critical analysis of the application of European Funds that are supposed to foster the economy. Despite the managing entity of the Incentive Programme studied, IAPMEI (2021), stating that projects of investment in mere expansion and modernization are not eligible, the clusters analysis on the innovations types show the tendency to a large number of applicants not bring anything new to the market not even considering only the Nacional market.

Moreover, this study makes a primary and critical analysis of the effects that the Incentive Programmes can have. It was found a much higher rate of the combination of different innovation types versus what was found by the European Commission (2019) on the *Annual Report on European SMEs 2018/2019*. This shows the encouragement that these incentives give to companies to complement more technological innovations with others (marketing and organisational). These combinations are found to be more efficient by several authors (Damanpour & Evan, 1984), and therefore, cause a positive impact on the future performance of the company.

Finally, quoting one of the most important researchers in the history of innovation studies "not to innovate is to die" (Freeman, 2013, p. 256). This is the closing line that reflects the importance of study innovation, its impacts but also being aware of its drivers to make a better management of the timings and outcomes. So, the findings of this study are important both to academic and practical fields, giving ideas of future investigation paths and allowing more conscious management of innovation. In addition to more evidence on the inputs to innovation, this study brings some reflections on the effects of certain criteria and the situation point of the projects applying to incentive programmes, such as the one studied. That said, both SMEs, consulting companies, and institutions benefit from a larger understanding of this subject.

Nonetheless, this study has some limitations that can constitute opportunities for future investigations. First, by using self-reported data, the dependent variables are sensible to the interpretation of the consultant and the SME that are responsible for the application.

Second, there is the impact of the client/project selection that the consulting company makes before even elaborating the application. Considering all incentives programmes present on the SI 2020, according to COMPETE (2021) in the *December 2020 Report*, the manufacturing sector applied to more than 22 million euros of investment out of the total 34 million (from all sectors). Moreover, projects with lower investments are not attractive because the incentives are not significant to cover the service expenses of contracting a consulting company. This leads to a biased sample, leaving out the target clients with smaller projects and companies from other sectors with less investment.

Lastly, the scope of the program studied (*SI Inovação Produtiva*) limits certain characteristics (such as the activity CAE) and encourage more types of innovation to be mentioned on the application (because it benefits the project's score). Initially, the objective was to include all four innovation types in the analysis but with more than 90% of the sample including these innovation types, no statistical conclusion could be made. According to the *Report of December 2020* on the Incentive Programmes, *Inovação Produtiva* only accounts for around thirteen thousand applications out of the total forty-five thousand of the SI 2020. Despite this, *SI Inovação Produtiva* is the most complete Incentive Programme, where companies can apply with the four different innovation types. Other incentive programmes previously mentioned, such as *SI Qualificação* and *SI Internacionalização*, have a larger number of applicants (more than half of the total according to the same report) but are too focused on marketing and organisational innovation, not covering product and process innovation.

For future research, this study opens doors to several paths. First, for further analysis with qualitative methodologies, such as interviews, to deepen some of the results obtained. Then, it would also be interesting to collect data from the decision (the final analysis made by an independent technician) instead of the application to mitigate the risk that certain innovation types could be wrongly classified. Another suggestion would be to comparate the results found in this study with a similar study with a sample from companies that didn't apply to European Funds to highlight the impacts of these funds and to understand if the results found in this study are also significant.

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Annex 1 - Levels of Qualification

Qualifications [Under the publication of Ordinance No. 782/2009, of 23 July, the National Qualifications Framework (NQF) was regulated]:

Level 1 – 2nd cycle of basic education.
Level 2 – 3rd cycle of basic education, obtained in regular education or through double certification classes.
Level 3 – Secondary education aimed at pursuing higher education.
Level 4 – Secondary education obtained through double certification classes or secondary education aimed at pursuing studies at a higher level plus professional internship - minimum of six months.
Level 5 – Post-secondary non-higher education qualification with credits for pursuing studies at the university level.
Level 6 – Degree.
Level 7 – Master.
Level 8 – PhD.