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Open Innovation, Coopetition and Co-innovation
How does co-creation interact?

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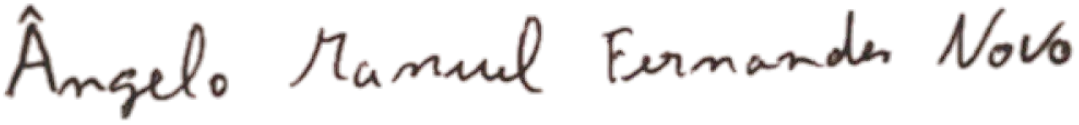

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Resumo

A adoção de práticas de inovação aberta implica que as ideias externas possam ser integradas nas atividades internas e assim expandir as operações, da mesma forma que as ideias que surgem internamente, com potencial aplicação em contextos externos, possam ser efetivamente partilhadas com parceiros de negócio ou outras organizações. A co-criação é um mecanismo poderoso que pode ser usado para gerar inovação, na medida em que combina o conhecimento de múltiplos colaboradores e facilita a transferência de conhecimento tácito. Isto porque as iniciativas de co-criação contribuem para a reunião dos participantes, bem como para o seu envolvimento activo no processo de inovação, integrando-os desde o início neste processo de construção partilhada. A coopetição é a capacidade das empresas de perseguir simultaneamente a cooperação e a competição entre organizações. A co-inovação é o processo que permite a participação dos diferentes intervenientes da empresa desde os clientes até aos fornecedores. Seguindo este raciocínio, este estudo visa avaliar empiricamente os padrões de interacção entre co-criação e co-inovação, tendo em consideração as estratégias de co-competitividade, isto é, de inovação aberta e de coopetição.

Uma amostra seleccionada de 13700 empresas incluídas no *Community Innovation Survey* 2018 de Portugal, é utilizada para estimar modelos multinomiais com variáveis de escolha discrete, nomeadamente o probit multinomial e o poisson multinomial, no sentido de avaliar as formas como a co-criação interage com a co-inovação na presença (ou ausência) de estratégias de inovação aberta e de coopetição.

A inovação aberta afecta positivamente a co-inovação, o que é ratificado na estimação dos três modelos de regressão em uso. Assim, na totalidade dos modelos, as variáveis: Licenciamento de propriedade intelectual a terceiros e Troca de propriedade intellectual; evidenciam efeitos positivos, embora apenas o primeiro seja estatisticamente significativo. Para além disso, a variável adquirida ou recebida através de patente ou licença de propriedade intelectual denota um efeito negativo, não obstante este não ser significativo para qualquer dos modelos estimados.

A coopetição também evidencia um efeito positive sobre a co-inovação, na medida em que nos três modelos estimados, os estimadores são positivos para duas variáveis representativas da coopetição, nomeadamente a empresa cooperou com outras empresas ou organizações em actividades de I&D, e a empresa cooperou com outras empresas ou organizações em outras actividades de inovação excluindo I&D e

cooperação de inovação parceira com um concorrente em Portugal. Contudo, esta última variável para empresas de bioeconomia só se mostra significativa na abordagem multinomial aplicada à inovação de processo.

Relativamente à co-criação, esta é significativa em todos os modelos e todos os coeficientes são positivos, embora as variáveis relacionadas com a inovação aberta e a coopetição quando combinadas (moderadas) com a primeira, apresentem sempre coeficientes negativos, quando se deteta significância estatística associada, quer seja na relação entre a inovação aberta e a co-inovação, quer seja na relação entre a coopetição e a co-inovação. Daqui resulta, duas descobertas interessantes, ou seja, que a co-criação, quando considerada de forma isolada como hipotético fator influenciador, interage positivamente com a co-inovação, no entanto, quando considerada como variável moderadora, a co-criação retarda a co-inovação.

Os resultados obtidos podem ser utilizados para criar novas políticas públicas com foco na dinamização da bioeconomia, baseadas nas relações entre: inovação aberta e co-inovação; coopetição e co-inovação; e ainda incorporando os efeitos positivos ou retardadores da co-criação.

Palavras-chave

Inovação aberta;Co-inovação; Coopetição;Cocreação;Inovação de processos;Inovação de produtos.

Abstract

The adoption of open innovation practices implies that external ideas can be integrated into internal activities and thus expand operations, just as ideas arising internally, with potential application in external contexts, can be effectively shared with business partners or other organizations. Co-creation is a powerful mechanism that can be used to generate innovation as it combines the knowledge of multiple employees and facilitates the transfer of tacit knowledge. This is because co-creation initiatives contribute to the bringing together of participants as well as their active involvement in the innovation process by integrating them from the beginning into this process of shared construction. Coopetition is the ability of companies to simultaneously pursue cooperation and competition between organizations. Co-innovation is the process that allows the participation of the company's different stakeholders from customers to suppliers. Following this *rationale,* this study aims to empirically evaluate the interaction patterns between co-creation and co-innovation, taking into consideration the strategies of co-competitiveness, i.e. open innovation and coopetition.

A selected sample of 13700 firms included in the Community Innovation Survey 2018 of Portugal is used to estimate multinomial models with discrete choice variables, namely multinomial probit and multinomial poisson, in order to assess the ways in which co-creation interacts with co-innovation in the presence (or absence) of open innovation and coopetition strategies.

Open innovation positively affects co-innovation, which is ratified in the estimation of the three regression models in use. Thus, in all models, the variables: Licensing of intellectual property to third parties; and Exchange of intellectual property; show positive effects, although only the first is statistically significant. Furthermore, the variable acquired or received through patent or intellectual property license denotes a negative effect, although this is not significant for any of the estimated models.

Coopetition also shows a positive effect on co-innovation, to the extent that in the three estimated models, the estimators are positive for two variables representative of coopetition, namely the firm cooperated with other firms or organizations in R&D activities, and the firm cooperated with other firms or organizations in other innovation activities excluding R&D and partner innovation cooperation with a competitor in Portugal. However, the latter variable for bioeconomy firms is only significant in the multinomial approach applied to process innovation.

Regarding co-creation, this is significant in all models and all coefficients are positive, although the variables related to open innovation and co-opetition when combined (moderated) with the former, always show negative coefficients, when associated statistical significance is detected, either in the relationship between open innovation and co-innovation, or in the relationship between co-opetition and co-innovation. This results in two interesting findings, namely that co-creation, when considered alone as a hypothetical influencing factor, interacts positively with co-innovation, however, when considered as a moderating variable, co-creation slows down co-innovation.

The results obtained can be used to create new public policies focused on boosting the bioeconomy, based on the relationships between: open innovation and co-innovation; co-opetition and co-innovation; and also incorporating the positive or slowingdow effects of co-creation.

Keywords

Open innovation;Co-innovation;Coopetition;Cocreation;Process innovation;Product innovation.

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1 - Introduction

The concept of open innovation was coined by Henry Chesbrough, a professor at the University of Berkeley in the United States of America (USA) and author of a book devoted to this challenging paradigm, which created a new research framework on the economics of innovation. The primary idea is precisely to open up the concept of innovation in such a way that there is collaboration among companies, individuals and public entities in the creation of a new product or service. For companies, it is a taboo that falls, in view that the research and development (R&D) activities have been kept under lock and are, usually, internal key-competitive factors.

To keep up with increasing technological complexity, bottom-line pressures, accelerating new product development, changing consumer expectations, and a volatile business environment, innovation is one of the key-resources for creating, responding to, and maintaining a competitive advantage. Innovation is necessary and probably the only way to survive. The new mantra of the economics of innovation is positioned as an open paradigm, considering that firms can leverage both external and internal ideas, as well as external and internal market pathways, as firms seek to advance their technologies (Chesbrough 2003). It was later redefined, the use of purposeful knowledge inputs and outputs to accelerate internal innovation, and expand markets for external use of innovation, correspondingly (Chesbrough et al. 2006).

Open innovation is presented as a successful approach to new product development (Chesbrough and Bogers 2014) that features purposefully managed knowledge inputs and outputs across organizational boundaries (Stanko, Fisher, and Bogers 2017). Many scholars highlight the benefits of such external collaboration (Markovic and Bagherzadeh 2018; Chesbrough 2020; Zhang and Xiao 2020).

Co-innovation acts in the field of value creation, it can be argued that innovation derives from the integration of external and internal resources, in order to generate value co-creation (Lee, Olson, and Trimi 2012). The previous research points out that co-innovation has different values for firms, such as increased market share and decreased time-to-market (Beelaerts van Blokland, Verhagen, and Santema 2008). Co-innovation also increases learning outcomes and knowledge of organizations (Westerlund and Rajala 2010). The recent advancement of Information and Communication Technologies (ICT) and the emergence of online communities has

facilitated value co-creation in online communities (Nambisan 2009). This new strategic approach places customers into work, allowing them to become co-innovators.

Co-innovation is not an isolated event, but a practice that is becoming increasingly important, in global terms, and may become the "standard" for innovation in the coming years. Co-innovation enables a company's different stakeholders (e.g. customers, suppliers, external collaborators, partner organizations, and citizens) to participate in the creation and development of new products and services, as well as processes and even business models through collaborative networks. Thus, co-innovation achieves value creation for the firm through the active participation of external actors (Lee, Romero, and Molina 2011; Olson, and Trimi 2012; Bugshan 2015; Saragih, Simatupang, and Sunitiyoso 2019).

Organizations appreciate the benefits of collaborating with others when they realize that their proposals to innovate and collaborate with others will lead to enhanced co-innovation. Co-innovation is an innovative trend that uses new technologies and external resources, such as customers, to jointly create value (Romero and Molina 2011).

The synergy between technological development and the evolution of management practices constantly redefines the roles of consumers and companies and generates new ways of integrating resources to create value (de Oliveira e Cortimiglia 2017). The interaction through the web allows the creation of new business models to create value based on the wisdom and knowledge of the masses. In this context, the market becomes an arena of interaction between customers and companies that together facilitate the co-creation of value, and their roles often overlap (Prahalad e Ramaswamy 2004). Co-creation can be just another differentiation source for a company, or it can be a fundamental mechanism for building a business model or even for innovating it.

Co-creation can also accelerate innovation in the face of disruptive digital technologies such as big data analytics, artificial intelligence (AI), or the Internet of Things (IoT) (OECD 2019). During the COVID-19 pandemic, co-creation initiatives are particularly important for creating the institutional environment necessary to co-create knowledge. These initiatives can be divided into two types: co-creation projects; and co-creation mechanisms. Co-creation projects aim to address specific challenges related to COVID-19 and involve participants from industry, research institutions and civil society (OECD Science and Industry 2021).

Coopetition consists of two contradictories, but interrelated, elements of cooperation and competition, which juxtapose into one phenomenon (Bengtsson and Kock 2014; Raza-Ullah, Bengtsson, and Kock 2014). These contradictory elements create a paradox that is considered an antecedent of tension (Raza-Ullah, Bengtsson, and Kock 2014). As a result, there are several studies on the paradox of coopetition, the types of tensions underlying this paradox, and how firms manage the paradox/tension within alliances. Numerous tensions arise in cooperative relationships, and the most common tensions in cooperative competition are related to roles, knowledge, power and dependence, and opportunism (Tidström 2014).

R&D collaboration within a coopetitive alliance is a collective process that should generate common interests shared by all the alliance partners. When these common interests are created and co-shared, power and dependency mechanisms can determine the distribution of knowledge among the different partners (Jakobsen 2020). Cassiman, Di Guardo, and Valentini (2009) found in their study on cooperative R&D projects that cooperation dominates knowledge creation activities, while competitive forces emerge in the distribution of this knowledge. Ritala and Hurmelinna-Laukkanen (2009) propose that knowledge creation has a greater potential for co-competitiveness than cooperation among non-competitors because firms share a large common knowledge base about markets and technologies.

In the current dissertation, co-innovation in bio-economy versus non-bio-economy companies is analysed, taking as reference a conceptual model of analysis, which proposes to assess the influence of open innovation on co-innovation, considering co-creation as a moderator variable. Moroeover, it assesess also the relationship between coopetition and co-innovation having again co-creation as a moderator variable. From the literature review, four research hypotheses are derived, namely: H1: Open innovation positively influences co-innovation; H2: Strategic coopetition among competitors positively influences co-innovation; H3: Co-creation moderates the relationship between open innovation and co-innovation; and H4: Co-creation moderates the relationship between coopetition and co-innovation.

In generic terms, this dissertation aims to assess the relationships among open innovation, co-opetition and co-innovation, considering co-creation as moderating variable. For this purpose, a literature review addressing each of the previously referred topics is presented, for supporting the empirical test. In specific terms, this research intends to assess whether co-creation moderates the relationships among open innovation, coopetition and co-innovation.

The remainder of the dissertation is structured as follows. Firstly, a literature review about open innovation, co-innovation, co-creation, and coopetition, is presented. After presenting the most relevant literature on these topics, a conceptual model of analysis is proposed. Secondly, a methodology section is presented, based on statistical data collected from the European Innovation Scoreboard (2018), in order to reveal the relative position of Portugal, compared to other European countries in terms of different innovation processes. In addition, an empirical approach is developed, by making use of three model specifications: OLS; multinomial Probit; and multilevel Poisson. Thirdly, the concluding remarks, implications, limitations, and guidelines for future research are made available.

2 - Literature review and hypothesis development

2.1 - Open innovation

2.1.1 - From closed innovation to open innovation

For years, the traditional rationale targeted to closed innovation has been tacitly seen as the "right way" model to bring new ideas into the market and successful companies. For most of the 20th century, this traditional model has worked, stating that companies consider that successful innovation requires control, i.e. companies must generate their own ideas that they will develop, manufacture, market, distribute and provide services on their own, this top approach requires self-reliance, since if you want something done right, you need to do it yourself (Chesbrough 2003).

Again, Chesbrough (2003) advocates that closed innovation is based on the view that innovations are developed internally. In this line of reasoning, the process occurs exclusively inside the company, from the creation of ideas to their development and marketing.

Innovation is not only the main factor for the technologies of companies in the market, but also the central driving force for sustainable development of companies (Yang, Lin, e Yang 2021). Innovation is defined as a repetitive process oriented to the combination of a set of unique skills (Hassan, Mostafa and Alireza 2014). Effective organizational innovation is a key-factor for creating and maintaining a competitive advantage, in order to tackle environmental changes and related developments (Sutanto 2017).

At the end of the 20th century, a number of factors combined to erode the fundamentals of closed innovation in the USA. One of the main factors was the dramatic increase in the number of workers and their mobility and knowledge, making it increasingly difficult for companies to control their ideas and to become owners of the knowledge. These factors have wreaked havoc on the virtuous cycle that underpinned closed innovation, since if a company that financed a breakthrough does not pursue it in a timely manner, the people involved can pursue it on their own (Chesbrough 2003).

In this context, the model of open innovation emerged, stating that a company markets both its own ideas and the innovations of other companies, as well as it searches for ways to bring its internal ideas to the market, implementing paths outside its current

business in order to generate value for the organization. In addition, the ideas can also originate outside the company's own laboratories and be conducted for marketing. In other words, the boundary between a company and its surrounding environment is more porous, allowing innovation to move easily between the two (Chesbrough 2003).

According to Laursen and Salter (2006), the organizations that are more open to external sources or research channels are more likely to have a higher level of innovative performance. Openness to external sources allows organizations to access third party ideas in order to deepen the amount of technological opportunities.

Following Enkel, Gassmann, and Chesbrough (2009), the use of open innovation in the commercialization process of companies has many advantages. For example, according to some studies, the use of open innovation can increase the product's success rate by 50% and the efficiency of internal R&D by 60%.

One of the main characteristics of open innovation is that it allows ideas and knowledge in the innovation process to be created on purpose across all organizational boundaries, along with the organization's business model (Oltra, Flor, and Alfaro 2018).

Entry practices are a kind of openness; external resources can be provided to the internal environment and companies can do this through procurement and acquisitions. Sourcing is an investment that does not involve monetary transactions and has an implicit synergy between internal processes and open information without strict financial responsibilities. Adding to the previous, procurement is an entry point that involves the exchange of money, including various forms of procurement technology and R&D work. With respect to exit practices, these are open types that allow internal resources to be supplied to the external environment. In terms of the impact of technology delivery strategies on environmental performance, the duality level allows firms to allocate and increase both their internal and external knowledge resources (Leitão, Pereira, and De Brito 2020).

2.1.2 - Evolution of the concept

Taking as reference the open innovation approach, which was originally coined and disseminated by Henry Chesbrough through the launch of the book titled: ‘Open Innovation’; in 2003, suggesting a less rigid boundary between the organisation and

the external environment, so that both benefit from the emergence of innovations. External ideas can be imported to leverage internal development and so expand operations, in the same way that ideas arising internally, with potential in other contexts, can be shared across borders. The knowledge flow coming into the organisation is called inbound, and the flow originating from the organization is denominated as outbound (Huizingh 2011).

Docherty (2006) presented a model that incorporates the main concepts of the innovation process to the open innovation approach proposed by Chesbrough (2003). In this same model, companies develop an inside-out look, and vice versa, through three main stages: (i) diffuse initiation; (ii) development; and (iii) marketing. According to the former author, this way of looking at innovation adds more value along the different processes of the value chain.

According to Chesbrough (2006), by using the open model, the company makes better use of the results of R&D activities, being able to apply it in its product portfolio, transferring technology to third parties or through a spin-off company, as well as being able to reach new markets and significant results.

This model assumes that knowledge to generate and promote innovation is found anywhere in the organisation's value network and in the globalised world, following the following set of principles: (i) Always be open to new ideas from outside, regardless of whether they come from research centres, universities, or even competing companies; (ii) Using external technology to promote its own internal R&D process, as well as to identify opportunities where other companies can take advantage of internal technology for the development of their business; (iii) R&D centres should deliver the new ideas and/or technologies that may emerge from suppliers, distributors, customers, etc.; (iv) Valuing intellectual contributions, whether from within or outside the company, facilitating the exchange of knowledge and incorporating technologies from others, sharing risks and benefits; (v) Promotion of innovation management through long-term sustainable processes and not just focusing on the launch of new products; (vi) Seeking external sources of innovation and having the ability to identify good ideas in their raw state so that they can develop and improve so that they have commercial potential and generate profit for the company; and (vii) Developing research structures that identify and hire the necessary skills to deal with problems and challenges difficult to revolve internally.

According to Bercovitz and Feldman (2007) innovation is the ability to create economic value from new ideas, and the pursuit of innovation requires companies to define a

strategy. A central concern in creating an innovation strategy is the required balance between the exploration of new ideas and the exploitation of existing skills and knowledge.

Open innovation not only leads the company to intensify relations with external organizations, but also involves the business model implementation as a device for decision-making (Chesbrough 2006). It should be noted that the organisational structure must be focused on the knowledge acquired in the innovation process. The creation of units or task forces independent of the company's business (Nohria 2004).

Recovering the Chesbrough (2010)'s vision, the future of open innovation depends on some perspectives, where some stand out, namely: (i) the greater specialization required to the labour force due to the more complex technologies and with a long-term focus; (ii) the clients' needs must be better understood and tools must be used for allowing the clients to create or configure its own product; (iii) the speed of innovations and the increase of competitiveness among companies are continuously evolving to guarantee their positions in the market; and (iv) R&D activities significantly contribute to technological progress.

Companies should not rely only on their own areas of internal planning and development of new goods and services (Hallstedt, Thompson, and Lindahl 2013). By acquiring advantage from external sources of technology and innovation, companies can drive domestic growth (Hellström et al. 2015). Open innovation presupposes that the knowledge, which promotes innovation is anywhere in a company's value chain (Chesbrough, 2003). Therefore, one path to innovation is to open the company's doors to ideas (Kian and Yusoff 2015) originating from external stakeholders, such as research centres, universities, suppliers and customers (Chesbrough and Schwartz 2007). Open innovation is a breakdown of values, in which knowledge is acquired through partners, that is, together they acquire the necessary skills to generate innovation and knowledge due to their complementarity (Chesbrough, 2006). In this sense, open innovation is aligned with knowledge management (Zemaitis 2014), which involves the use of mechanisms to help companies in order to manage knowledge as an asset that promotes business development (i.e., Seethamraju and Marjanovic 2009) and innovation that generates learning and knowledge sharing, which can help companies' development (Cui et al. 2015).

A great deal of literature in recent years has emphasized the absolute importance of the search for external knowledge and the efficient recombination of knowledge to innovate (Chesbrough and Bogers 2013; Mina, Bascavusoglu-Moreau, and Hughes 2014;

Neirotti, and Appio 2017). Openness to collaborate with external actors throughout the innovation process, however, does not come without challenges: recent studies also suggest that openness to innovation significantly increases the risks of imitation and that such risks are present at all stages of the innovation process (Veer, Lorenz, and Blind 2016).

High levels of open entry positively moderate the relationship between open entry innovation and technical performance, while decreasing the effects of open entry innovation on market performance. These results show that the trade-offs between open input and output innovation depend on the performance objectives of the project. For fostering market performance, high open input combined with low open output is optimal. However, if the goal of an open-source software project is to improve its technical performance, then high levels of open output innovation are beneficial when the input openness is high (Tang, Fisher, and Qualls 2021).

In subsequent terms, it is presented a brief summing-up of the main reference authors and contributions, devoted to the concept of open innovation (please see Table 1, below).

Table 1 - Open innovation concept: Reference authors and contributions

Reference Authors	**Contributions**
Chesbrough 2003	Innovators must integrate their ideas, experience, and skills with those of others outside the organization to deliver the result to the market, using the most effective means possible. In short, companies that can leverage external ideas to further their own business while leveraging their internal ideas outside their current operations are likely to thrive in this new era of open innovation.
Docherty 2006	If you embrace the principles of open innovation and learn to successfully implement these collaborative methods into your culture and organization, you will create your own "next big thing"; and more importantly, a steady stream of innovation drives new sources of growth. And the personal rewards of working with many other creative minds besides your own.
Bercovitz and Feldman 2007	While companies can leverage all types of cross-border alliances to gain distinctive knowledge, evidence suggests that universities are the preferred partners when there are concerns about the perceived ability to take full ownership of the results. This is particularly true for exploration-based projects. Companies that focus

	on exploratory research are engaging in a risky long-term strategy. The fact that universities have different objectives than companies can provide unique strategic partnership opportunities.
Chesbrough 2010	Organizations will need to identify internal leaders for business model changes in order to manage the results of these processes and provide the company with new and better business models. If local goals are to be subordinated to organization-wide goals, the discretion and judgment of mid-level managers must be based on empirical data. At the same time, the organizational culture must find a way to embrace the new model while maintaining the effectiveness of the current business model until the new model is ready to take over completely. Only in this way can business model innovation help companies get rid of the "traps" of previous business models and restore growth and profits.
Hallstedt et al. 2013	Decision makers seeking to manage product development in a more sustainable way, exploring how product development companies can introduce a strategic sustainability perspective into their product innovation process. Furthermore, it takes place at an intermediate level between sustainability on a corporate level and sustainable product innovation on a design level.
Buys et al. 2014	The ability to use existing industry measures and global environmental, economic and social indices suggests the Sustainability Scorecard can be used for standardized comparisons with similar industries in other countries, although it has the ability to be customized at the local level for developing and testing improvement strategies. The ability to use existing industry measures and global environmental, economic and social indices suggests the Sustainability Scorecard can be used for standardized comparisons with similar industries in other countries, although it has the ability to be customized at the local level for developing and testing improvement strategies.
Cui et al. 2015	In an increasingly competitive and fast-paced environment driven by new developments in information technology, open innovation will remain relevant. New challenges will arise, requiring a deeper understanding of companies implementing open innovation.
Veer et al. (2016)	For companies that collaborate during the idea generation phase, patents are an enablement of imitation, rather than a mitigation. These results indicate that patent-intensive companies need to find different ways to protect their intellectual property from imitation when entering collaborations in the idea generation phase. Design and trademark protection offer a superior alternative to patents for the idea generation phase, as suggested by our estimates. We suggest that in the context of research and development cooperation, the enabling effect of

	patents is of particular importance in the idea generation phase, although it is less relevant in later stages of collaboration.
Tang et al. (2021)	Open inbound innovation hinders the technical performance of the project (i.e. the progress of the open source software development), but improves the market performance (i.e. the user adoption of the open source software product).

2.1.3 - Partnerships for open innovation

The involvement of different types of partners affects innovation performance. When seeking external knowledge, organizations make strategic choices concerning the type of partner from which they could seek new knowledge and technologies (Katila, Rosenberger, and Eisenhardt 2008). For its turn, this choice can affect the company's innovation performance (Fabrizio 2009; Natalicchio et al. 2017).

In the context of the selection problem for choosing the right partner, Laursen and Salter (2006) propose to search diverse channels, whereas Brown and Duguid (2000) suggest that every search channel is an individual search arena, which consequently requires distinct norms, rules and practices for search efforts to become productive. According to Ebersberger, Bloch, Herstad and Velde (2012), firms search among customers and competitors, for increasing their understanding of the market and the direction of market change, and among universities, research institutes, suppliers, and again competitors for building possible solutions or new directions to explore.

Following Laursen and Salter (2004) universities are valuable innovation partners, especially in creating radical innovations (Fabrizio 2009), but this also depends on the size of the company and the level of investment in R&D (Laursen and Salter 2004; Fabrizio 2009). For Faems, Van Looy, and Debackere (2005), cooperation with universities and research institutions can be considered as exploratory cooperation, as such type of cooperation generally focuses more on the development of new technologies. Fey and Birkinshaw (2005) also provide evidence that university cooperation is directly proportional to the company's R&D performance. Belderbos et al. (2014) have found that innovation in collaboration with universities (measured in terms of co-ownership patents) is associated with increased market value.

Universities are organisations that play a fundamental role in contemporary societies, educating large proportions of the population and generating knowledge. Recently, often on the initiative of policy makers, many universities have taken steps to develop a

'third mission', promoting links with knowledge users and facilitating technology transfer (Etzkowitz et al., 2000; Gulbrandsen and Slipersæter, 2007). Academic involvement represents an important form of transfer of academic knowledge to industry; many companies consider it significantly more valuable than licensing university patents (Cohen, Nelson, and Walsh, 2002). University income from academic involvement is usually a high multiple of income derived from intellectual property (Perkmann, King, and Pavelin 2011).

One model through which we can interpret these changes is the `three-fold propeller' (Etzkowitz and Leydesdorff 1999). A triple helix of university-industry-government relations transcends previous models of institutional relations, whether laissez-faire or socialist, in which the economy or the predominant politics, with the knowledge sector playing a subsidiary role. The triple helix model tries to account for a new configuration of emerging institutional forces in innovation systems, whether through the decline of the total state or the opening up of the island corporation.

Most policy actions to support the development of university-industry interactions in several European countries were premised on the argument that universities were not doing enough to develop activities relevant to economic development. These policies were informed by the large body of literature dealing with third stream activities, such as the Triple Helix model (Leydesdorff and Etzkowitz 1996; Etzkowitz 2001).

The triple helix model can be divided into a model of nationalism, a laissez-faire model and an interactive model. In the first model, the state includes universities and industries, establishing a direct relationship with them. At this point, the government acts as coordinator, providing and coordinating resources for the new plan. However, in general, government intervention is considered excessive, so this model is considered unsuccessful. In the second model, that is, the laissez-faire one, the three pillars operate independently, and the relationship between them is relatively loose. The university has a background in basic research and talent development and, when focused on the private sector, the company creates standard knowledge. Even without cooperation with companies, universities can discover and create useful knowledge. In the third model, that is, the interactive model, universities, governments and companies play many roles in this process. In the process of sharing, new innovative knowledge and revolutionary ideas have emerged, and each actor has an horizontal relationship. This is the core concept of the triple helix model, in which the interaction and cooperation among universities, industry and government, as relatively equal

partners, has been strengthened, and the resulting innovation and development reinforced social and economic development (Nam, Kim, and Choi 2019).

The Triple Helix model of innovation focuses on university-industry-government relationships, emphasizing knowledge production and innovation as a result of fruitful interactions between academia, business and institutions. The Quadruple Helix model of innovation (Carayannis and Campbell 2009) incorporates the Triple Helix by adding the "media and culture-based public" and "civil society" as a fourth helix. The Quadruple Helix already encourages the knowledge society perspective, and knowledge democracy for knowledge production and innovation. In the scope of the Quadruple Helix framework, the sustainable development of a knowledge economy requires coevolution with the knowledge society (Maruccia et al. 2020).

Adding to the previous statements, it is worthwhile to outline that the Quadruple Helix framrwork has its roots in the triple helix model of innovation that envisions an entrepreneurial university, interacting and exchanging knowledge with industry and government in an open innovation framework (Etzkowitz and Klofsten 2005). Indeed, the rise of the knowledge economy paradigm and the non-linear and open innovation methods have inspired and strengthened this concept (OECD 1996). The triple helix framework helped to design and implement innovation policies around the world. However, some scholars have pointed out its uneven results in supporting economic growth in the region (Miller et al. 2016; McAdam e Debackere 2018), and narrowly focused on limited institutional areas (Lindberg, Danilda, and Torstensson 2012). The quadruple helix framework attempts to overcome these weaknesses and integrate civil society, which is not only considered a dynamic social environment for innovation, but also an additional and vital participant in the innovation process (Kolehmainen et al. 2016). It should be emphasized that the quadruple helix partnership is not static. Its composition is characterized by the presence of old or emerging actors with mixed roles between the public and private sectors and between the social and commercial fields (Bellandi, Donati, and Cataneo 2021).

A notable development is the latest link between the quadruple helix framework and the concept of social innovation (Carayannis et al. 2019). Although the latter is increasingly relevant in academic and policy debates (Howaldt, Kaletka, and Schröder 2016), it has been difficult to find a single, consistent definition in the scientific literature (van der Have and Rubalcaba 2016). Social innovation sets out to establish new social relationships and new forms of governance based on alternative forms of understanding, action, and organization (Moulaert, MacCallum, and Hillier 2013),

which helps address unwarranted social challenges (Avelino et al. 2019). Due to the complex and multidimensional nature of climate change, aging population, income inequality, and social exclusion, it is purely a matter of failure or non-intervention of state or market driven mechanisms (Bellandi et al. 2021).

Questions have arisen about the nature of the dynamics of internal social innovation and quadruple helix collaboration. How the subjects involved interact, decision-making, and cooperation are still unclear (Calzada 2018). In fact, the quadruple helix framework is mainly used to analyse the macrostructure of helix relationships at the national and regional levels (Mulyaningsih 2015; Lew, Khan, and Cozzio 2018). Until recently, scholars extended the analysis to the micro level of the interaction mechanism between different quadruple helix actors (Höglund and Linton 2018; Hasche, Höglund, and Linton 2020). The concept of social innovation ecosystem is considered a support that social innovation can provide surrounding, unfolding and spreading, this can be a heuristic model to understand the complex dynamics of the interactions and co-creations involved (Howaldt et al. 2016). However, further analysis is needed to unveil the role played by each actor, as well as the interests of divergent actors and any agendas that may hinder such processes (Domanski, Howaldt, and Kaletka 2020).

The Quintuple Helix model of innovation is even broader and more comprehensive, contextualizing the Quadruple Helix and adding the helix (and perspective) of the 'natural environments of society'. The Fivefold Helix emphasizes the necessary socio-ecological transition of society and economy in the 21st century; therefore, the Quintuple Helix is ecologically sensitive. In the Quintuple Helix model of innovation, society and the natural environments of the economy should also be seen as drivers of knowledge production and innovation, thus defining opportunities for the knowledge economy (Maruccia et al. 2020).

The theme of the innovation ecosystem based on the pillars of the Quintuple Helix model has recently been used to analyse programs that support the development of social innovation based on the «location-centric and three-centric process of baseline knowledge discovery and exploitation» (Carayannis et al. 2019, page 1). Describing the regional development model through the fivefold spiral means that the region is considered an ecosystem occupied by organizational and institutional stakeholders. This type of stakeholders usually have conflicting socio-political, economic, technological, and environmental interests, but must move toward a converging goal (Carayannis et al. 2018). This is a reminder of the need for dynamic configurations on the agendas of policymakers operating as facilitators of an entrepreneurial ecosystem

based on knowledge and technology clusters, universities and innovation networks (Grundel and Dahlström 2016; Carayannis et al. 2018).

In today's "knowledge economy", product innovation has become a crucial strategy for business survival and development, as the introduction of new products can create new markets and growth opportunities (Lagrosen 2005; Xie and Jia 2016).

Meanwhile, in the context of economic globalization, industry integration and rapid technological change, external innovation research has become particularly important for companies seeking to develop new products (Cassiman and Valentini 2016; Lin et al. 2020). As a result, several industries have shifted their focus from individual products and services to complex value propositions, whereby participating companies interact with each other to create value and form sustainable ecosystems consisting of actors, assets and connections (Adner 2006; Adner and Kapoor 2010).

Innovation activities are rarely found in isolation. Instead, these types of activities are often part of broader changes in a company's environment, requiring innovation from various actors to insert a company into an interdependent innovation ecosystem (Adner, 2006; Adner and Kapoor, 2010).

An innovation ecosystem is defined as a weakly interconnected network of companies and other entities that co-evolve capacities around a shared set of technologies, knowledge or skills and work cooperatively and competitively to develop new products and services (Nambisan and Baron, 2013).

Adner (2017) advocated that a business ecosystem is an aligned structure consisting of a set of multilateral partners that need to interact with each other to achieve a focal value proposition. For its turn, Reynolds and Uygun (2018) noted that a high level of interaction between key entities (e.g., universities, suppliers, customers/users and competitors) in an innovation ecosystem is likely to play a significant role in building innovation capacity. Adding to the previous statements, Song (2016) proposed that a focal company’s external links with its suppliers, complementary companies, customers and competitors play a vital role in the company's performance within its innovation ecosystem. In addition, previous research has suggested that contemporary product innovation has increasingly relied on the interdependence of companies participating in innovation ecosystems (Adner 2006; Adner and Kapoor 2010).

Adner (2017) has determined that a business ecosystem consists of a group of multilateral business partners that need to interact to achieve recommendations of

focal value. In addition, Becker and Dietz (2004) noted that the impact of R&D cooperation on innovation activities is better explained by companies working in the technology partner network system than by cooperating unilaterally with only one partner, since, due to the heterogeneity of several partners, a single collaborative system is produced. Furthermore, Robaczewska, Vanhaverbeke, and Lorenz (2019) argue that open innovation is no longer just an "inside-in" or "inside-out" relationship with a single partner, but a set of interrelated stakes, which promote and maintain the ecosystem, leading to innovation that creates multidisciplinary knowledge.

The entrepreneurial ecosystem is a group of independent participants and factors that coordinate with each other to enable entrepreneurship in a specific field. In this same ecosystemic framework, open innovation refers to the conscious use of both internal and external knowledge flows, in order to to accelerate internal innovation, market expansion and external use of innovation (De Brito and Leitão 2021).

The identification of open innovation as the predecessor of the entrepreneurial ecosystem is based on a series of studies developed based on the application of interrelated concepts of small and medium enterprises (SMEs), absorptive capacity, collaboration, and knowledge management. For clusters and innovation, it has also turned out to be the precursor of the entrepreneurial ecosystem, which operates through the application of related concepts such as networks, regional innovation systems, knowledge and knowledge spillovers (De Brito and Leitão 2021). Therefore, because of the role played by knowledge spillovers in product and process innovation, it is not surprising that the former are becoming increasingly important for entrepreneurship. The associated advantage is that firms can be more entrepreneurial and innovative with less effort and costs (Lee, Choo, e Yoon 2016).

2.2 - Co-innovation

2.2.1 - Co-innovation depending on open innovation

Co-innovation is not an isolated event, but a practice that has become increasingly important on a global scale and may become the "standard" of innovation in the coming years. The root cause is simple: the world and the market are too complicated for us to solve on our own. No matter what economic sector you are in, the complexity of creating new value for customers and consumers requires a combination of

knowledge that our company and industry cannot control. Collaboration becomes the smartest way to compete.

Co-innovation is defined as the process that allows the participation of the different stakeholders of the company (customers, suppliers, external collaborators, partner organizations and the general public), through collaborative networks, in the creation and development of new products and services, as well as processes or even business models; that is, co-innovation achieves the creation of value for the company through the active participation of external actors (Lee, Romero and Molina 2011; Olson, and Trimi 2012; Bugshan 2015; Saragih, Simatupang, and Sunitiyoso 2019). Four levels of action and collaboration are identified as sources of innovation, that is, the individual, the team, the organizations, and the community.

Therefore, co-innovation is related to two apparently different but basically complementary approaches: open innovation and collaborative innovation. Open innovation focuses on the importance of continuous innovation brought about by the development of internal and external knowledge and ideas (Chesbrough 2003). For its turn, collaborative innovation emphasises the innovation process carried out through the building of partnerships and alliances with other actors, where participating partners share ideas and knowledge (Bonney et al. 2007). In short, co-innovation is based on the connection with multiple actors, since innovation resulting from collaboration or participation is much more effective than that undertaken alone.

Lee et al. (2012) argued that business should focus on integration, collaboration and co-creation to develop co-innovation. Convergence is the possibility of a network of co-innovation bringing together different participants so that new products, processes and business models can be developed collaboratively sourced on the complementarity of resources and functions (Bitzer and Bijman 2015). In turn, collaboration requires the development of a culture based on collaborative work within the company; it thus facilitates the building of relationships that foster the creation or joint learning of knowledge with other actors in the co-innovation network (Tomlinson 2010; Walsh, Lee, and Nagaoka 2016; van den Broek, Boselie, and Paauwe 2018).

In this context, the design and management of the co-innovation platform is particularly relevant for maintaining a collaborative innovation cycle with real value creation potential for the company, which means being attentive to the three aspects related to business participation in the collaborative innovation network. According to Gloor (2006) and Abhari, Davidson, and Xiao (2017) these dimensions are creativity or ideation collaboration, and communication.

In essence, co-innovation is seen as a way to synergize the efforts and investments of internal and external partners to create valuable new products, processes, or services (Baldwin and von Hippel 2011). Tsou, Cheng, and Hsu (2015) with regard to co-innovation as a mechanism for producing or improving products or services for customers, from a service delivery perspective, it can create value for customers through product and service integration. In addition, co-innovation is also seen as a three-dimensional process: cooperation of participants; complementary integration of technologies, organizations, and institutions; and coordination among all levels of the value chain (Bitzer and Bijman 2015).

In a related vein, Yeniyurt, Henke, and Goksel (2014) use the term co-innovation to deal with vertical collaborative processes involving suppliers in new product development; and demonstrates that co-innovation has a positive impact on performance measured through new product launches and sales.

The co-innovation paradigm suggests that firms should develop collaborative networks, often through the creation of alliances and structured partnerships, in order to share knowledge, know-how, and resources to develop collaborative innovations (Lee, Olson, and Trimi 2012). Firms use open innovation processes to acquire (formally and/or informally) knowledge and resources from external partners, especially other firms and universities, in order to develop innovations (Chesbrough 2003; Bogers and West 2012; Tranekjer 2017).

The co-innovation is focused on identifying and exploiting the potential exchange of ideas and resources that can be unleashed by using all possible physical and digital collaborative channels, and involving all potential categories of stakeholders as well as the entire collaborative ecosystem of the firm (Lee et al. 2012; Lozada, Arias-Pérez, and Perdomo-Charry 2019; Chen et al. 2020). Considering the previous statements, the first research hypothesis is derived:

H1: Open innovation positively influences co-innovation.

2.2.2 - Strategic Coopetition

Since the mid-1990s, coopetition has been defined as the simultaneous pursuit of cooperation and competition among organizations, and has received increasing attention from researchers as a new form of interorganizational relationship (Bengtsson and Kock 2014a; Bouncken et al. 2015). Nalebuff and Brandenburger

(1996) stress that cooperation and competition can be part of the same relationship, and they also use the concept of competition to describe this relationship. Organisations engage in coopetition, seeking competitive and cooperative activities simultaneously, due to various environmental factors.

Coopetition is a phenomenon that seeks cooperation and competition between companies at the same time, and is becoming increasingly popular in academia and practice. The performance of the contradictory logic of cooperation and competition in the same relationship makes competition a self-contradictory relationship (Bengtsson and Kock 2014; Bengtsson, Raza-Ullah and Vanyushyn 2016; Jakobsen 2020; Raza-Ullah 2020), where the part of cooperation that emphasizes collective interest to create greater value coexists with the part of competition that emphasizes private gains that create value (Raza-Ullah, Bengtsson and Kock 2014; Gnyawali, Madhavan, He and Bengtsson 2016). The juxtaposition of these two equally important but interrelated contradictory logics in the relationship, makes the contradiction of collusion self-contradictory (Jakobsen 2020).

Co-operation is defined as a strategic and dynamic process in which economic actors jointly create value through co-operative interaction, while simultaneously competing to capture part of that value (Bouncken et al. 2015). Co-operation is also conceived as a network of value (Nalebuff and Brandenburger 1996), a dyadic relationship (Bengtsson and Kock 2000), a paradox (Raza-Ullah et al. 2014), a business model (Ritala and Sainio 2014), and an ecosystem (Bengtsson and Raza-Ullah 2016).

In the business relationship within the network, the trade-off between cooperation and competition stands out, which is a means of generating progress among participants in long-term relationships. Nevertheless, the trade-off between cooperation and competition between competitors needs further study.

Fruitful cooperation must be carefully managed to balance the interaction between cooperation and competition (Park, Srivastava, and Gnyawali 2014; Bouncken et al. 2015). Cooperation is an interconnected activity where individual and organisational perceptions and experiences influence organisational operations, the interconnections between competitors and the outcome resulting from competition (Bengtsson and Kock, 2000).

At the individual level, when cooperation begins, managers must decide with whom to cooperate. How relationships in co-operative networks are built on trust and mutuality (Bengtsson and Kock 1999), previous personal connections between decision-makers

and previous successful associations; trust between top managers; strong commitment; similar status and ease of communication are among the criteria for selecting partners that managers use at the individual level (Das and He 2006), setting the basis for coopetition success (Alves and Meneses 2015).

When coopetition is established, managers should use relational skills and management leadership (Chin, Chan, and Lam 2008) to enable knowledge sharing and value co-creation among the company network (Ngugi, Johnsen, and Erdélyi 2010). Leading the co-operative process is not easy as managers seek both private and common benefits (Khanna, Gulati, and Nohria 1998; Park et al. 2014), share information and resources while protecting knowledge leakage (Ho and Ganesan 2013).

As many of the most successful strategic alliances are formed between rivals (Harbison and Pekar 1998), coopetition, along with other types of interorganisational relationships, remains important in modern business.

Cooperation can be observed at both intra and inter organisational levels, the latter being classified into two types, namely dyad and network (Bengtsson and Raza-Ullah 2016). In both cases, the nature of coopetition is to extend the total benefit through cooperation as a struggle to appropriate a larger share of the benefit as competitors (Nalebuff and Brandenburger 1996). Cooperation can be observed ubiquitously (Gnyawali, He, and Madhavan 2006) in various company activities (Bouncken et al. 2015).

When it comes to knowledge-sharing in competitive environments, we know that this can cause sharing tensions versus protection between partner companies, which eventually requires a combination of legal, formal and informal protection mechanisms to address them (Estrada, Faems, and de Faria 2016; Chiambaretto, Massé, and Mirc 2019).

One of the most effective measures to manage such tension is to separate activities involving cooperation and competition (Bengtsson and Kock, 2000; Kock, 2000). Companies usually cooperate in areas of work that are not visible to their customers, while competing for customers through activities that are visible and recognizable to customers. However, such a separation may reduce the synergies achieved through cooperation (Stadtler and Van Wassenhove 2016). Therefore, according to Le Roy and Fernandez (2015), Fernandez and Chiambaretto (2016), it is important to integrate cooperative and competitive activities at the team level, while still separating these two elements at the organisational level.

The main motivation of firms to participate in coopetition can be attributed to the need to overcome environmental conditions (Luo 2007; Gnyawali and Park 2011; Gnyawali and Ryan Charleton 2018), in order to improve their competitive advantage (Bengtsson e Kock 2000; Gnyawali and Ryan Charleton 2018; Gast, Gundolf, Harms and Matos Collado 2019) and, thus, to be able to survive in a competitive business environment (Hoffmann, Lavie, Reuer and Shipilov 2018). The two methods of cooperation and competition can be viewed simultaneously from the perspective of contradiction (Bengtsson, Raza-Ullah, and Vanyushyn, 2016; Makhashen et al. 2020), since the latter is pointed out as a basic condition for fostering competition. However, it may not be easy for companies to engage in the paradoxical duality. Among other things, flexible managers may be needed (O'Reilly and Tushman 2011; Bengtsson et al. 2016; Felício, Caldeirinha, and Dutra 2019), altough prepared to do two opposite things at the same time.

Leitão and Pereira (2016) studied the coopetition relationships between Portuguese and Italian firms and concluded that, coopetition schemes within the country reveal that it is of utmost importance that firms engage in coopetition schemes for better performance in innovation generation (for both Italian KIS and LKIS and Portuguese LKIS). Considering coopetition relations with rival firms abroad, the results partially confirm the hypothesis that the later act as determinants of firm's innovation.

Coopetition schemes with rival firms abroad, namely in China and India, have a positive and significant impact on firm's innovation (Leitão e Pereira 2016). Considering the previous empirical findings, it results the following research hypothesis:

H2: Strategic coopetition among competitors positively influences co-innovation.

2.2.3 – Co-creation

The emergence of co-creation theory has devoted an increasing importance to the role played by consumers in value creation, providing a new perspective for understanding value creation in the supply chain. The development of the internet, big data and other technologies further promote the practice of value co-creation in supply chains (Kakhki and Gargeya 2019). This trend had a profound impact on the evolution and technological change of many industries, especially the electronics and semi-conductors industries.

The concept of co-creation can be defined as the union of actors across organizational boundaries to create mutually beneficial outcomes. Co-creation broadens the scope of innovation and development, providing increasingly empowered roles for participants and institutional arrangements (Verschuere, Brandsen, and Pestoff 2012; Voorberg, Bekkers, and Tummers 2015).

Co-creation, co-production, continuation (Ritzer and Jurgenson 2010) and collaborative experiences have a similar theoretical basis because they are based on active participation/intervention in the process of creation and consumption. Despite conceptual differences between co-creation and co-production discussed by some scholars, such as Ertimur and Venkatesh (2010) and Chathoth et al. (2016), these are used indistinctly in related literature.

Co-creation focuses on the company's ability to involve its clients in the value creation process, either by creating new products or services or by developing those it already has (de Oliveira and Cortimiglia 2017). Thus, the intensive use of ICT has allowed the co-innovation process to advance and consolidate itself, thus facilitating the approximation between different participants that are usually scattered in different geographical locations. In other words, the involvement of actors to promote the development of the various tasks in the co-innovation process is possible through the use of technologies and social mechanisms (de Oliveira and Cortimiglia, 2017).

Creativity or ideation refers to the participation of actors in the co-creation of new products or services. The focus of cooperation is on challenges and problem solving through the participation and interaction of internal and external participants in the co-innovation network. Finally, communication is conceived as the process that ensures the fluidity in the exchange or creation of knowledge from the interacting actors.

The significance of the possibilities provided by the co-innovation platform refers to the ease and functionality with which actors perceive the different uses and interactions of the various tasks related to the co-innovation cycle when interacting through the technological platform designed to manage it, including the collaborative idea of submission, evaluation and development of co-invention activities (Abhari et al. 2017).

Co-creation with the customer, also called "co-design" or "co-development", is a product development approach in which customers actively participate in the design of their product (Prahalad and Ramaswamy 2004). Companies have turned to co-

development to improve their ability to identify and meet customer needs, increasing the success of new products (Franke, Keinz, and Steger 2009).

Value co-creation embraces different types of value, whether they are monetary gains or social benefits for the company or client; different processes, e.g. co-creating companies or a company co-creating with its client; and different actors, e.g. main users, a multitude of clients, communities, etc. (Franke, Keinz, and Schreier 2008; Saarijärvi, Kannan, and Kuusela 2013).

Galvagno and Dalli (2014) analysed co-creation and identified three main theoretical perspectives for co-creation research: service science; marketing and consumer research; and innovation and technology management. Bharti, Agrawal, and Sharma (2015) used thematic content analysis to identify 27 elements of cocreation and divided them into five categories: process environment; resources; coproduction; perceived benefits; and management structure. Leclercq, Hammedi, and Poncin (2016) conducted a comprehensive review of value cocreation from the disciplines of innovation, business, and marketing. In the following years, other studies complemented these initial attempts, using bibliometric techniques and adopting common methods (Alves, Fernandes, and Raposo 2016; Ribeiro, Tavares, and Costa 2016; Saha, Mani, and Goyal 2020).

Other works analyse value cocreation in specific fields, such as tourism (Campos et al. 2015; Tregua, D'auria, and Costin 2020), public services (Voorberg et al. 2015; Capolupo, Piscopo, and Annarumma 2020) or healthcare (Greenhalgh et al. 2016; Aghdam et al. 2020), or related to specific issues, such as the process of value cocreation in web-based platforms (de Oliveira and Cortimiglia 2017) or value cocreation in online communities (Priharsari, Abedin, and Mastio 2020).

Co-creation is essential to deliver services that are growing day by day, not only in service-related industries. In this same line of action, managers should consider value co-creation a priority on their agenda. Nájera-Sánchez, Ortiz-de-Urbina-Criado, and Mora-Valentín (2020) highlight the new roles that customers have taken, since they are now positioned as innovators, sources of information, co-producers, communicators, and even more. Companies need to learn what kind of customer can play these roles, how to manage each of these roles, and how much participation is optimal for the company.

Nájera-Sánchez, Ortiz-de-Urbina-Criado, and Mora-Valentín (2020) advocate that the service sector is a relevant benchmark in what concerns the value co-creation process.

In the tourism, utilities, and healthcare sectors, value co-creation has grown exponentially in recent years. Interaction with customers in the design or production of services has become essential for companies in these sectors.

In this line of reasoning, co-creation is a powerful mechanism for generating innovation because it combines various collaborators' knowledge and promotes the transfer of tacit knowledge. This is because co-creation initiatives bring participants together and actively involve them in the innovation process from the beginning, integrating them into the innovation process. This contrasts with the transaction-based knowledge transfer, which is targeted to exchange knowledge that is codified in licenses or patents. Another relevant feature is that stakeholder participation in the research process increases the applicability of research and the chances of successful adoption. It can also promote better integration of scientific progress with industry and/or societal needs (OECD science and industry 2021).

Co-creation can also accelerate innovation in the face of disruptive digital technologies such as big data analytics, artificial intelligence (AI), or the Internet of Things (IoT). The need for more cooperation between different types of participants is actually one of the characteristics of innovation in the digital age, because innovation in the new environment often needs to go beyond traditional departments or disciplinary capabilities, preventing to limit the capabilities of universities and industries (such as human capital, finance, facilities, etc) (OECD 2019).

During the COVID-19 pandemic, co-creation initiatives were particularly important for creating the adequate institutional environment necessary for knowledge co-creation. These initiatives can be divided into two types: co-creation projects; and co-creation mechanisms. The co-creation initiates allowed to solve specific challenges related to COVID-19, by involving participants from industry, research institutions, and civil society. The operational focus was developing vaccines, creating open data repositories, and developing specific products, such as fans. The co-creation mechanisms provided the necessary infrastructure to contact experts, create temporary teams, and enable the mobilization of diverse participants to address the range of challenges raised by COVID-19. Notable examples of such mechanisms are digital platforms, social innovation hubs and hackathons. While other relevant co-creation initiatives can focus on addressing local, regional, national, or global levels of challenges, mechanisms tend to focus on addressing national or global challenges (OECD science and industry 2021).

From the previous statements, the following research hypotheses are derived:

H3: Co-creation moderates the relationship between open innovation and co-innovation.

H4: Co-creation moderates the relationship between coopetition and co-innovation.

2.3 – Conceptual model proposal

Based on the literature review previously presented, we propose a conceptual model of analysis that integrates the research hypotheses that are presented below in figure 1. This conceptual model of analysis aims, on the one hand, to operationalize the test of the relationship between open innovation and co-innovation and the relationship between coopetition and co-innovation, and on the other hand, moving forward the still limited knowledge on the role played by co-creation when interacting with co-innovation, by introducing an innovative feature, which consists in testing the hypothetical moderating effect of representative variables of co-creation.

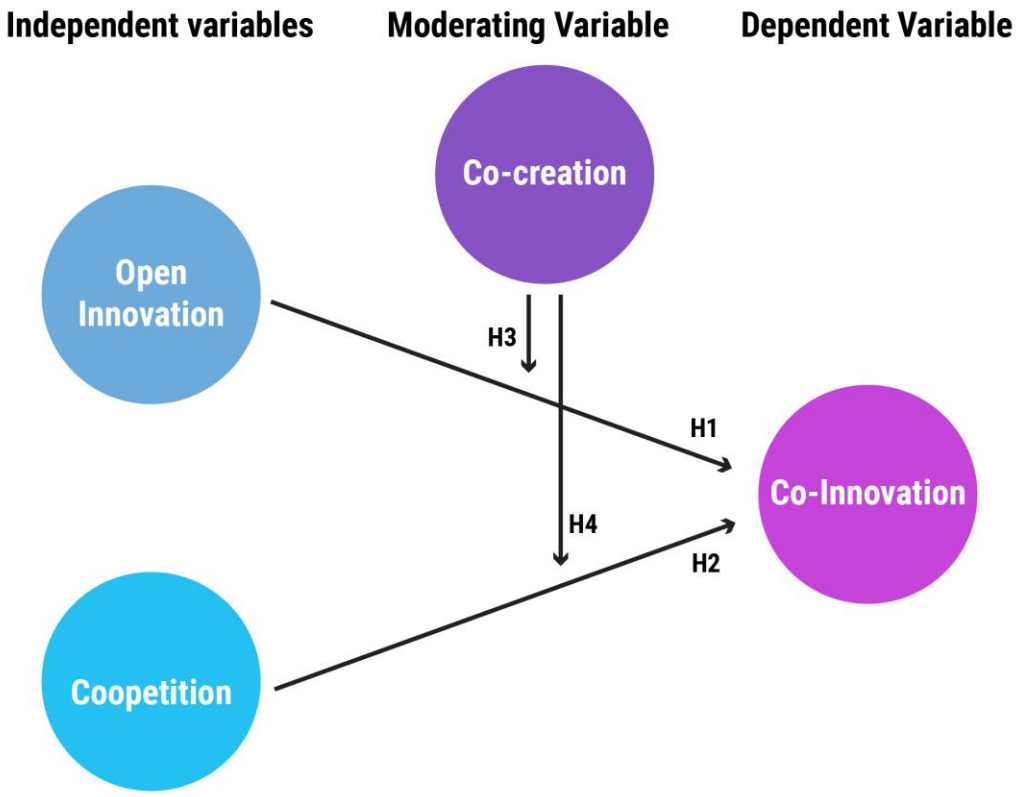

Figure 1 - Influencers of Co-innovation: conceptual model proposal

3 - Methodology

3.1 – Data Framework: European Innovation Scorecard

According to the European Innovation Scoreboard (2018), the difference in terms of economic structure is particularly important, in the sense that the difference in the share of industry in GDP and the so-called high-tech activities of manufacturing and service industries are important factors that explain why countries perform better or worse on the macroeconomic fundamentals, as well as innovation indicators, such as corporate R&D expenditures, patents, and innovative firms. The advanced technology intensity of medium- and high-tech industries is higher than that of other industries. On average, this industry will have higher R&D expenditures, more patent applications, and more shares of innovative firms. Countries with above-average market shares in these industries are expected to perform better on several indicators from the Community Innovation Survey (CIS).

For example, for the EU28, on average 85% of R&D expenditure in manufacturing is accounted for by medium-high and high technology manufacturing. Furthermore, the share of firms that have introduced a product and/or process innovation is higher in medium-high and high-tech manufacturing compared to all core industries covered in the CIS (European Innovation Scoreboard 2018).

Foreign ownership, including ownership in other EU and non-EU member states, is important because, on average, about 40% of R&D expenditures of companies in EU member states are carried out by foreign subsidiaries, which compares with major international competitors An indicator measuring the percentage of value added by foreign-controlled companies can be used as a proxy indicator of the difference in the economic impact of foreign ownership (European Innovation Scoreboard 2018).

The infllaw of new technologies is important because they contribute to economic and technological capabilities. Domestic and foreign direct investment (FDI) can have a positive impact on innovation performance, although it depends on the complexity of the industry recipient, political and economic conditions, and the quality of host country institutions. Inward FDI flows are measured by average net inflows over a three-year period, i.e., the average net inflows of investments that obtain long-term management equity (10% or more voting shares) from companies operating in

economies other than those of the current investors (European Innovation Scoreboard 2018).

Firm characteristics are important in explaining the difference between R&D expenditures and innovation activities. Large firms (defined as firms with 250 or more employees) account for almost four-fifths of EU firms' R&D spending, while small and medium-sized firms, defined as firms with 10 to 249 employees, account for only one-fifth. The EU Industrial R&D Investment Scoreboard records the existence of a large number of R&D investors. The scoreboard provides economic and financial data and analysis of R&D investors in leading EU and foreign firms. Political and economic conditions and the quality of host country institutions. Inward FDI flows are measured by average net inflows over a three-year period, i.e., the average net inflows of investments that obtain long-term management equity (10% or more voting shares) from companies operating in economies other than those of the current investors (European Innovation Scoreboard 2018).

Demand is an important driver of innovation. According to the Oslo Manual (2018), demand factors shape innovation activity in two major ways: (i) for new product development, as firms modify and differentiate products to increase sales and market share; and (ii) for improving production and supply processes to reduce costs and lower prices. The World Economic Forum's Executive Opinion Survey includes an indicator that provides a measure of individual consumers' preferences for innovative products. The degree of buyer sophistication measures on a scale of 1 (low) to 7 (high) whether buyers focus more on price or quality of products and services.

Adding to the previous, governments play an important role in enhancing the innovation capabilities of an economy. Government procurement of advanced technology products measures the extent to which government procurement decisions promote technological innovation - from 1 (not at all) to 7 (extremely effectively). Trust is important for creating a business environment for undertaking risky innovative activities. The rule of law captures differences in the extent to which people have confidence in and abide by the rules of society. Rule of law measures differences in the quality of contract enforcement, property rights, police and courts, and the likelihood of crime and violence.

The performance of the EU's national innovation systems is measured by the Innovation Summary Index (European Innovation Scoreboard 2018), which is a composite indicator obtained by taking an unweighted average of the 27 indicators. The data below shows the scores for the Summary Innovation Index for all EU Member

States in 2018, 2017 (previous year), and the reference year 2011. Based on the scores in the year 2018, the Member States are divided into four performance groups:

- The first group of Innovation Leaders includes 4 Member States where performance is above 120% of the EU average. The Innovation Leaders are Denmark, Finland, the Netherlands and Sweden;

- The second group of Strong Innovators includes 8 Member States with a performance between 90% and 120% of the EU average. Austria, Belgium, Estonia, France, Germany, Ireland, Luxembourg, and the UK are Strong Innovators;

- The third group of Moderate Innovators includes 14 Member States where performance is between 50% and 90% of the EU average. Croatia, Cyprus, Czech Republic, Greece, Hungary, Italy, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia, Slovenia and Spain belong to this group;

- The fourth group of Modest Innovators includes 2 Member States that show a performance level below 50% of the EU average. This group includes Bulgaria and Romania.

For Moderate Innovators, performance has been increasing since 2014, with growth accelerating in 2017 and 2018. Compared to 2011, average performance improved by 9.0 percentage points, which is slightly higher than the average performance increases for both Innovation Leaders and Moderate Innovators.

For Portugal, performance decreased 2.8 percentage points, with a decrease in performance between 2010 and 2014 not being fully offset by increased performance between 2015 and 2017, but increased strongly by 12.6 percentage points, with a strong increase in performance in 2018 (13.3 percentage points), entirely due to highly improved performance for the six indicators using CIS data.

Performance of the EU innovation system, measured as the weighted average of the performance of the innovation systems of all 28 Member States, has improved by 8.8 percentage points between 2011 and 2018.

In the dimensions of innovators and sales impacts, strong innovators perform better. In other aspects, the performance gap between different countries may be small. In terms of employment impact, the performance gap between innovation leaders and powerful innovators is relatively small compared to the average gap in all dimensions. Between strong innovators and average innovators, the difference in performance is relatively

small for the innovation-friendly environment and employment impact. Between medium and medium innovators, the performance gap in environmental innovation, knowledge assets, and employment impact is relatively small. Performance The difference between leading innovators and powerful innovators is relatively high in terms of human resources and attractive in terms of environmental innovation.

Performance differences between Strong Innovators and Moderate Innovators are relatively high for attractive research systems and connections. Performance differences between Moderate Innovators and Modest Innovators are relatively high for firm and innovative investments.

The country rankings for Human Resources and attractive research systems are close to the overall ranking of the performance groups. This also holds true, although to a lesser degree, for Finance and Support and Connections. The dimensions of innovation-friendly environment, innovators, employment impact and sales impact are more deviant from the overall rankings. The firm's knowledge assets and investment dimensions also deviate from the overall rankings, but to a lesser degree. These deviations indicate that the country may perform well on certain dimensions while its overall performance is low, leading it to belong to a group with low innovation performance. Similarly, leading innovators may underperform in one dimension, but may compensate for these relative weaknesses with stronger performance in other dimensions.

The human resource performance largely reflects the overall ranking of the four performance groups. In 2018, all four innovation leaders were in the top five. With the exception of Germany, all the powerful innovators performed above the EU average. Most of the medium-sized innovators perform below the EU average, with only Spain and Slovenia performing above the EU average. The performance of the medium innovators is below the EU average, Romania is the worst performer, but Bulgaria's performance is better than the three medium innovators. In the case of Portugal the performance decreased by 23.1% between 2010 and 2017. The EU average increased by 19.3% between 2010 and 2017 and increased 2,4% netween 2017 and 2018.

Performance in attractive research systems largely reflects the overall ranking of the four performance groups. In 2018, the performance of the four innovation leaders was much higher than the EU average. With the exception of Germany and Estonia, all the powerful innovators performed above the EU average. Most mid-range innovators performed below the EU average, and only Cyprus and Portugal performed above the EU average. Moderate innovators performed poorly, occupying the last two positions in

the performance rankings. The EU average increased by 1.2% between 2016 and 2017 and increased by 0.2% between 2017 and 2018.

Performance in innovation-friendly environment deviates from the overall ranking in four performance groups. In 2018 the Innovation Leaders are the best performing countries, occupying all the top 4 positions. Strong Innovators were more dispersed, with Belgium and Luxembourg performing above the EU average, and the other Strong Innovators below the EU average. Moderate Innovators show strong performance on this dimension, in particular Malta, Portugal, Poland, Lithuania and Spain, who all perform above the EU average. For Modest Innovators, this is a relatively strong innovation dimension, with Bulgaria performing above two and Romania at six Moderate Innovators. Portugal in 2017 had a performance increase of 74.2%. The EU average increased by 15.6% between 2016 and 2017 and between 2017 and 2018 it increased by 13.2.

Financial and support performance reflects to some extent the overall ranking of the four performance groups. In 2018, the innovation leaders performed better than the EU average, but not all countries performed better on this indicator. The top five innovators performed better than the EU average, with France leading the way. The performance of the three powerful innovators is below the EU average. The performance of all mid-level innovators is below the EU average. The performance of the middle innovators is below the EU average, and Romania's performance is better than the three middle innovators. The EU average increased by 9.4% between 2011 and 2018. Compared to 2017, performance improved for only 18 Member States, with the highest rate of increase in performance for Portugal (17.2). The EU average remained the same between 2017 and 2018.

Performance in Firms investments departed to some extent from the global ranking in four performance groups with two Leading Innovations in the top 5; the Netherlands as the Innovation Leader and several of the Strong Innovators performed below the EU average. Germany was the leading set, and the Modest Innovators performed the worst. The EU increased on average by 19.2% between 2011 and 2018 and increased by 8.8% between 2017 and 2018.

In the year 2018 performance on the Innovators dimension deviates from the overall ranking in four performance groups. Portugal, a Moderate Innovator, was the best performing country overall. Three other Moderate Innovators were performing above the EU average, which were Greece, Italy and Lithuania. Finland was the only Innovation Leader in the top-10, and Denmark was underperforming the EU average.

Compared to 2017, performance improved for 20 Member States, with Portugal showing the second largest performance increase (56.6%). The EU average decreased by 9.2% between 2011 and 2018, but increased by 4.0% between 2017 and 2018.

Performance on the links reflects to some extent the overall ranking in four performance groups. In 2018 the Innovation Leaders were represented among the top group of countries, along with Strong Innovator countries Austria and Belgium which ranked first and second. Three Strong Innovators were performing below the EU average, which were Luxembourg, Ireland and France. Three Moderate Innovators - Greece, Lithuania and Slovenia - performed above the EU average. The EU average increased by 3.9% between 2011 and 2018 and between 2017 and 2018 it increased by 1.6%.

Performance on intellectual assets in 2018 departed to some extent from the global ranking in four performance groups. Malta, a Moderate Innovator, was the best performing country overall. Three Innovation Leaders and Luxembourg, a Strong Innovator, occupied the other top 5 positions, with Denmark in second place and Luxembourg in third. with Ireland, one of the Strong Innovators, performing well below the EU average. Three other Strong Innovators performed below the EU average, which are the UK, France and Belgium. The EU average decreased by 2.7% between 2011 and 2018 and decreased again by 1.9% between 2017 and 2018.

Performance on employment impact in 2018 deviated from the overall ranking in four performance groups with only one Innovation Leader, Sweden, in the top five performing countries. Ireland, a Strong Innovator, was the best performing country, followed by Malta, a Moderate Innovator. Most Innovation Leaders, except Finland, outperform the average EU. Bulgaria, a Modest Innovator, shows a strong performance above the EU average. Strong Innovators Austria, Estonia, Belgium, France and Germany all performed below the EU average. Between 2010 and 2017 Portugal's performance increased by 33.6%, however it decreased by 2.2% between 2017 and 2018. The EU average increased by 4.4% between 2011 and 2018 and 4.5% between 2017 and 2018.

Performance in terms of sales impact in 2018 deviated from the overall performance group ranking in four performance groups. All Innovation Leaders perform below the EU average. The top three performing countries included three Strong Innovators: Ireland, Germany and the UK. Slovakia and Cyprus, both Moderate Innovators, were also among the countries performing well on this dimension. The Strong Innovators are also scattered with four performing above the EU average and four performing below

the EU average. Modest Innovators performed below the EU average, but Romania performed relatively well, better than 5 Moderate Innovators. The EU average increased by 3.0% between 2011 and 2018, but decreased by 1.8% between 2017 and 2018.

3.2 – Model specifications

In the scope of the current empirical approach four models are used, namely the Ordinary Least Squares (OLS), Multinomial Probit Regression, Multilevel Poisson regression and Multilevel negative binominal regression, considering the same dependente variables and a selected set of independent variables, which were collected from the CIS 2018 survey with a sample of 13701 Portuguese companies.

The goal of linear regression using the OLS model is to estimate the parameters of the linear conditional mean

$$Yi = \beta 1 + \beta 2\ X2i + \beta 3\ X3i + \ldots + \beta k\ Xki + ui; \quad (1)$$

or, in a more convenient notation,

$$Yi = Xi\ \beta + u \quad (2)$$

Where: Xi is the vector (1×k) of components 1, X2i, X3i, …, Xki and β is the vector (k×1) of regression coefficients), and let Yi denotes a binary variable coded with the value 1 or the value 0. Usually, the value 1 is assigned to the presence of a certain attribute in the ith observation, while the value 0 is assigned to its absence. From another perspective, the two possible values can be seen as corresponding to the verification, or not, of a certain event by the 1st observation. In this case the dependent variables range from 0 to 2.

Often, as in this case, the OLS model is only used as a way to predict the expected results of the tests that will be done later.

The Multinomial Probit Regression is obtained from the Additive random-utility (ARUM) model by assuming normally distributed errors.

For the ARUM, the utility of alternative *j* is given by:

$$U_{ij} = x'_{ij}\beta + z'_i y_j + \varepsilon_{ij} \quad (3)$$

where the errors are assmned to be normally distributed, with $\in \sim N(0, \sum)$ where $\in = (\in_{iI}, \ldots, \in_{im})$.

The probability that alternative *j* is chosen equals to:

$$Pij = \Pr(yi = j) = Pr\{\in_{ik} - \in_{ij} \leq (x_{ij} - x_{ik})'\beta + z'_i(y_i - y_k)\}, \text{ for all k} \quad (4)$$

Following Cameron (2009) this is an *(m - I)* dimensional integral for which there i s no closed-form solution and computation is difficult. This problem did not arise for the preceding logit models because for those models the distribution of *e* is such that ordered outcome models has a closed-form solutionWhen there are few alternatives, say three or four, or when $\sum = \sigma^2 I$, quadrature methods can be used to numerically compute the integraL Otherwise, maximum simulated likelihood, discussed below, is used.

Regardless of the method used, not all (m + 1) m/2 distinct entries in the error variance matrix, $\sum$, are identified. From ordered outcome models, the model is defined for m - 1 error differences ($\in_{ik} - \in_{ij}$) with an (m - 1) x (m - 1) variance matrix that has m(m - 1)/2 unique terms. Because a variance term also needs to be normalized, there are only {m(m - 1) /2} - 1 unique terms in $\sum$. In practice, further restrictions are often placed on $\sum$, because otherwise $\sum$ is imprecisely estimated, which can lead to imprecise estimation of β and y.

According to Al-Balushi et al. (2020) the multilevel Poisson regression model for a count $Y_{ij}$for individual i in group j can be written as:

$$Y_{ij}/\lambda_{ij} = Poisson(m_{ij}, \lambda_{ij}) \quad (5)$$

The standard link function for the Poisson distribution is the logarithm, expressed by:

$$n_{ij} = ln(\lambda_{ij}) \quad (6)$$

The level 1 and level 2 models can then be constructed as

$$n_{ij} = \beta_{0j} + \beta_{1j} X_{ij}, \quad (7)$$

Where:

$$\beta_{0j} = \beta_0 + \mu_{0j} \; ; \; \beta_{1j} = \beta_1 + \mu_{1j} \quad (8)$$

yielding

$$n_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + \mu_{0j} + \mu_1 X_{1j} \quad (9)$$

Since the Poisson distribution has only one parameter, specifying an expected count that also implies a specific variance. Hence, the first-level equations do not have a lowest-level error term.

Overdispersion suggests that there is more variation in the response than the model implies. Under a Poisson model, we would expect the means and variances of the response to be about the same in various groups. Without adjusting for overdispersion, we use incorrect, artificially small standard errors leading to artificially small p-values for model coefficients. We may also end up with artificially complex models (Brockmann 1996).

We can take overdispersion into account in several different ways. The simplest is to use an estimated dispersion factor to inflate standard errors. Another way is to use a negative-binomial regression model. We chose to use the negative binomial model. An advantage of this approach is that it introduces another parameter in addition to λ, which gives the model more flexibility and, as opposed to the quasi-Poisson model, the negative binomial model assumes an explicit likelihood model.

3.3 – Variables

In the current empirical approach, the dependent variables are represented through the following variables: (I) Process innovation: B0701 (The company itself developed process innovation) and B0702 (The company in cooperation with other companies or

organizations developed process innovation); (II) Product innovation formed through the variables B0401 (The company itself developed product innovation); and (III) Co-innovation B0402 (The company in cooperation with other companies or organizations developed product innovation). The dependent variables range from 0 till 2, when the value equals to zero it means that the company does not make process/product innovation, when the value is equal to 1, it means that the company makes innovation only within the company itself or only with other companies, when the value is equal to 2, the company makes innovation within the company itself and with other companies.

The independent variables used are based on three main pillars: (i) Open innovation (represented by the variables, i.1 - Licensed your intellectual property rights to others, i.2 - Exchanged intellectual property rights (Ex:.pooling, cross-licensing, etc.), and i.3 - Purchased or received licensing of patents or intellectual property rights); (ii) Co-creation (represented by the variables ii.1 - Goods or services created together with users, i.e. the user participated in the creation of the idea, design and development of the producto, ii.2 - Co-creation and/or customization of these goods or services resulted from the participation/solicitation of companies (includes private companies, private universities, private for-profit research institutes, and public for-profit companies), and ii.3 - Products that resulted from customization or co-creation); and (iii) Coopetition (represented by the variables, iii.1 - innovation cooperation partner with a competitor in Portugal, iii.2 - the company cooperated with other companies or organizations in R&D activities, and iii.3 - the company cooperated with other enterprises or organizations in other innovation activities (excluding R&D)).

In the table 2 below are represented the codes of the variables used in the model specifications, as well as their respective designations. Variables A0601, A0603 and A0701 belong to open innovation, variables B1501, B1502 and b1610 belong to co-opetition, variables A and B are the dependent variables belonging to co-innovation, all the others are variables moderated by co-creation.

Table 2 - Variables: Code and designation

Code	Designation
A0601	Licensed your intellectual property rights to others
A0603	Exchanged intellectual property rights
A0701	Purchased or received licensing of patents or intellectual property rights
B1501	The company cooperated with other companies or organizations in R&D activities
B1502	The company cooperated with other enterprises or organizations in other innovation activities (excluding R&D)
B1610	Innovation cooperation partner with a competitor in Portugal

ccc	Co-creation variable (formed by coupling the variables A0201 and A0301)*
cccxA0603	Exchanged intellectual property rights moderated by co-creation
cccxA0701	Purchased or received licensing of patents or intellectual property rights moderated by co-creation
cccxB1501	The company cooperated with other companies or organizations in R&D activities moderated by co-creation
cccxB1502	The company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation
cccxB1610	Innovation cooperation partner with a competitor in Portugal
A	Process innovation
B	Product innovation

*Note: A0201 – Goods or services created together with users, i.e. the user participated in the creation of the idea, design and development of the product; and A0301 - Co-creation and/or customization of these goods or services resulted from the participation/solicitation of companies (includes private companies, private universities, private for-profit research institutes, and public for-profit companies).

3.3 – Datasets and sector classification

In the current empirical approach, three different datasets are used, one of them containing the total available sample, and the other two divided between bioeconomy firms and non-bioeconomy firms, this allocation was made through a sector classification, taking as reference the methodological procedure adopted in Leitão et al. (2020). A description of the sector classification can be seen in table 2 displayed below

Table 3 - Sector classification: National Classification of Economic Activities-NACE Rev.2

Classification	Description	NACE Code Rev.2
Bioeconomy firms	Agriculture	A01
	Forestry	A02
	Fishing and aquaculture	A03
	Production of food, drinks and tobacco	C10; C11; C12
	Production of biologically-based cloth, clothing and leather	C13 *; C14 *; C15
	Production of wooden products and wooden furniture	C16; C31 *
	Production of paper	C17
	Prodution of biologically-based chemial products pharmaceutical products and plastic and rubber	C20*; C21*; C22*
	Bio-ethanol production	C2014 *
	Bio-diesel production	C2059 *
	Bio-electricity production	D3511 *
Non-bioeconomy firms	Mines and quarries	B05-B09
	Printing and reproduction of recorded media	C18
	Production of coke and derivatives of refined oil	C19

Prodution of biologically-based chemial products; basic metals; manufactured metal products, except machinery and equipment; computer, eletronic and optical products; eletrical equipment; etc	C23; C24; C25; C26; C27; C28; C29 C30; C32; C33
Supply of electricity, gas, steam and air conditioning	D35
Supply of water; drains, waste management and remediation	E36-E39
Construction	F41-45
Wholesale and retail commerce; Repair of motor vehicles and mobikes	G45-G47
Transport and storage	H49-H53
Accommodation activities and food services	I55-I56
Information and communication	J58-J63
Financial activities and insurance	K64-K66
Real estate activities	L68
Professional, scientific and technical activities	M69-M75
Administrative and support service activities	N77-N82
Public administration and defence and obligatory social security	O84
Education	P85
Human health and social work activities	Q86-Q88
Arts, entertainment and recreation	R90-R93
Other activities and services	S94-S96
Activities of households as employes	T97
Activities of foreign organisations and entities	U99

*. Hybrid sector.

Source: withdrawal from Leitão et al. (2020)

4 - Results Discussion

4.1 - Total sample

Initially in the discussion of results, the results for the total sample are presented, starting with the descriptive statistics, then the correlations, and finally the regression results of the three models estimated, that is, OLS model, multinomial probit, and multilevel poisson[1].

According to the Table 4 presented below, we can verify that the total sample embraces 13701 companies, which are located in Portugal. All variables are binary variables, the variables: licensed your intellectual property rights to others (A0601); purchased or received licensing of patents or intellectual property rights (A0701); exchanged intellectual property rights (A0603); the company cooperated with other companies or organizations in R&D activities (B1501); the company cooperated with other enterprises or organizations in other innovation activities excluding R&D (B1502) and innovation cooperation partner with a competitor in Portugal (B1610) range between 0 and 1, all other variables vary between 0 and 2. With the observation of the averages of the remaining variables we can conclude that these have many more values with zero than with one, since all the averages of the binary variables are less than 0.5. Regarding the VIF, which allow us to test the multicollinearity of the variables, since all values are less than 10, and the average of these same value is less than 5, there is no a potential multicollinearity issue.

Table 4 - Descriptive statistics for total sample

	Obs	Mean	Std. Dev.	VIF	1/VIF
A	13,701	0.400701	0.6540248		
B	13,701	0.303773	0.5910337		
A0601	13,701	0.014816	0.1208221	1.04	0.9644
A0701	13,701	0.021531	0.1451524	1.26	0.7786
A0603	13,701	0.002774	0.0525931	1.94	0.5165
B1610	13,701	0.010218	0.1005712	2.42	0.4137
B1501	13,701	0.071528	0.2577135	2.75	0.363
B1502	13,701	0.056492	0.2308782	2.85	0.3509
ccc	13,701	0.33888	0.6947971	1.29	0.7737
cccxa0603	13,701	0.00219	0.0603725	1.92	0.5214
cccxb1610	13,701	0.010072	0.13686	2.42	0.4137
cccxb1501	13,701	0.067951	0.3463825	3.31	0.3023
cccxb1502	13,701	0.056127	0.3173612	3.29	0.304
cccxa0701	13,701	0.007518	0.1127706	1.28	0.7786

[1] Please consult the appendix for a summary of the results discussion.

Bearing in mind that the detection of a strong correlation means mutual relationship between two terms. To correlate, therefore, means to have a certain type of relationship. Thus, the linear correlation method is used to assess the joint behavior of the pairs of variables under study.

Looking at tables 5 and 6, we can see that the correlation levels between the variables undergo some changes with the change in the dependent variable in question. Although there are some relatively high values, as is the case of the correlation relations between exchanged intellectual property rights (A0603) - exchanged intellectual property rights moderated by co-creation (cccxa0603); the company cooperated with other companies or organizations in R&D activities (B1501) - the company cooperated with other companies or organizations in R&D activities moderated by co-creation (cccxb1501); the company cooperated with other enterprises or organizations in other innovation activities excluding R&D (B1502) - the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) and innovation cooperation partner with a competitor in Portugal (B1610) - innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610), for both dependent variables, these do not present any potential issue of homocedasticity for the models to be estimated, since all these values are lower than 0.75.

Table 5 - correlation of A for total sample

	A	**A0601**	**A0701**	**A0603**	**B1610**	**B1501**	**B1502**	**ccc**	**ccca0603**	**cccxb1610**	**cccxb1501**	**cccxb1502**	**cccxa0701**
A	1												
A0601	0.0967	1											
A0701	0.0021	0.0026	1										
A0603	0.0441	0.1543	0.0113	1									
B1610	0.1575	0.0296	0.0049	0.0084	1								
B1501	0.3487	0.0996	0.0174	0.05	0.3069	1							
B1502	0.3412	0.0563	0.0051	0.0532	0.2769	0.5172	1						
ccc	0.3557	0.0741	0.0022	0.0342	0.0946	0.2441	0.2306	1					
cccxa0603	0.0388	0.0956	0.0113	0.6877	-0.0037	0.0462	0.0435	0.0693	1				
cccxb1610	0.1286	0.0219	-0.0072	-0.0039	0.7243	0.2321	0.2061	0.1621	-0.0027	1			

cccxb 1501	0.3096	0.0841	0.0101	0.0377	0.2357	0.7068	0.4138	0.422	0.0697	0.3397	1		
cccxb 1502	0.2792	0.0449	-0.0009	0.0344	0.2039	0.4025	0.7228	0.3848	0.0698	0.2945	0.5988	1	
cccxa 0701	0.0601	0.0293	0.4494	0.0211	-0.0003	0.0493	0.0285	0.1305	0.0405	-0.0002	0.0747	0.0372	1

Table 6 - correlation of B for total sample

	B	**A0601**	**A0701**	**A0603**	**B1610**	**B1501**	**B1502**	**ccc**	**cccxa 0603**	**cccxb 1610**	**cccxb 1501**	**cccxb 1502**	**cccxa 0701**
B	1												
A0601	0.1169	1											
A0701	-0.003	0.0026	1										
A0603	0.041	0.1543	0.0113	1									
B1610	0.1627	0.0296	0.0049	0.0084	1								
B1501	0.383	0.0996	0.0174	0.05	0.3069	1							
B1502	0.3514	0.0563	0.0051	0.0532	0.2769	0.5172	1						
ccc	0.4251	0.0741	0.0022	0.0342	0.0946	0.2441	0.2306	1					
cccxa 0603	0.0407	0.0956	0.0113	0.6877	-0.0037	0.0462	0.0435	0.0693	1				
cccxb 1610	0.1318	0.0219	-0.0072	-0.0039	0.7243	0.2321	0.2061	0.1621	-0.0027	1			
cccxb 1501	0.3776	0.0841	0.0101	0.0377	0.2357	0.7068	0.4138	0.422	0.0697	0.3397	1		
cccxb 1502	0.3325	0.0449	-0.0009	0.0344	0.2039	0.4025	0.7228	0.3848	0.0698	0.2945	0.5988	1	
cccxa 0701	0.0544	0.0293	0.4494	0.0211	-0.0003	0.0493	0.0285	0.1305	0.0405	-2E-04	0.0747	0.0372	1

The OLS model is not a model capable of explaining the variables under study, it is only The OLS model is not a model capable of explaining the variables under study, it is only used as a predictive model, for a first screening purpose, so that we are able to perform a first screen of the expected signal of the coefficients, as well as their associated statistical significance.

By observing table 7 and 8 referring to the OLS model for the dependent variable process innovation (A), and product innovation (B), correspondingly, we can find similarities, for all normal independent variables we can see that for both variables it is expected that all of them are significant at 1% in the models to be developed with the exception of Purchased or received licensing of patents or intellectual property rights (A0701) and Exchanged intellectual property rights (A0603), which for both dependent variables are not significant. As for the independent variables moderated by co-creation, some differences are already noticed, for variable A it is expected that only the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) is significant in the following models, however for variable B, in addition to the variable cccxb1502 also the innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610) is statiscally significant.

With regard to the coefficients, it is detected a greater effect on variable product innovation (B), since all the statiscally significant coefficients are higher than those presented in the model for process innovation (A), with the exception of the company cooperated with other enterprises or organizations in other innovation activities excluding R&D (B1502), the company cooperated with other companies or organizations in R&D activities (B1501), and the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502).

Table 7 - OLS regreesion for all sample for variable A

A	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
A0601	0.248827***	0.041376	6.01	0	0.1677255	0.3299293
A0701	-0.04197	0.037949	-1.11	0.269	-0.1163501	0.03242
A0603	0.177999	0.129892	1.37	0.171	-0.076608	0.4326054
B1610	0.229906***	0.075233	3.06	0.002	0.0824386	0.3773729
B1501	0.433439***	0.031619	13.71	0	0.3714612	0.4954173
B1502	0.641005***	0.035898	17.86	0	0.5706406	0.711369
ccc	0.262068***	0.008033	32.62	0	0.2463217	0.2778147
cccxa0701	0.078551	0.049336	1.59	0.111	-0.0181544	0.1752565
cccxa0603	-0.09292	0.112612	-0.83	0.409	-0.3136592	0.1278101
cccxb1610	-0.05771	0.05577	-1.03	0.301	-0.1670228	0.051609
cccxb1501	0.025154	0.02578	0.98	0.329	-0.0253783	0.0756866
cccxb1502	-0.15322***	0.028055	-5.46	0	-0.2082139	-0.098231
_cons	0.246135	0.005673	43.39	0	0.2350157	0.2572544

Legend: ***1% significance; **5% significance; *10% significance.

Table 8 - OLS regreesion for all sample for variable B

B	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
A0601	0.300306***	0.035901	8.36	0	0.229935	0.3706777
A0701	-0.030974	0.032928	-0.94	0.347	-0.0955176	0.0335689
A0603	0.099014	0.112706	0.88	0.38	-0.1219065	0.3199334
B1610	0.366628***	0.065279	5.62	0	0.2386724	0.4945842
B1501	0.385697***	0.027436	14.06	0	0.3319193	0.4394749
B1502	0.425745***	0.031148	13.67	0	0.3646905	0.4867993
ccc	0.276635***	0.006971	39.69	0	0.2629717	0.2902979
cccxa0701	-0.016853	0.042809	-0.39	0.694	-0.1007637	0.0670572
cccxa0603	-0.115094	0.097712	-1.18	0.239	-0.3066232	0.0764358
cccxb1610	-0.247787***	0.048391	-5.12	0	-0.3426396	-0.152935
cccxb1501	0.107076***	0.022369	4.79	0	0.0632297	0.1509228
cccxb1502	-0.029927	0.024343	-1.23	0.219	-0.0776424	0.0177887
_cons	0.147863	0.004922	30.04	0	0.1382147	0.157511

Legend: ***1% significance; **5% significance; *10% significance.

Tables 9 and 10 provide the results concerning the multinomial probit model estimations, for variables A and B, respectively. This model is divided into two levels, one for when the dependent variable equals to *1* and another for when the variable equals *2*. When the variable is equal to 1 it means that the company practices process/product innovation within the company itself or with other companies or organizations, when the variable is equal to 2 it means that the company in question simultaneously practices innovation within the company itself and with other companies or organizations.

With regard to the coefficients and their significance, it is observed that they are almost identical to the one presented in the OLS model. In the model for process innovation (A), Exchanged intellectual property rights (A0603), which was not significant before, becomes significant for 5% when the variable is equal to 1.

Through the analysis of table 9 we can verify that for process innovation (A) for both levels, all independent variables that are staistically significant influence process innovation, in a positive way, however the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) influences in a significantly negative way the process innovation. In other words, the moderation of co-creation in the relationship between firms cooperating with other firms or organizations in innovation activities (excluding R&D) and co-innovation is slowindown process innovation.

For product innovation (B) we can notice some differences, for both levels of B unlike what was seen in the previous OLS model the company cooperated with other

companies or organizations in R&D activities moderated by co-creation (cccxb1501) is no longer significant and the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) that was not significant became significant for both levels. As in process innovation, the same set of independent variables denote a significantly positive influence on product innovation. Nevertheless, the moderating variables negatively influence it, being innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610) and cccxb1502, this means that co-creation combined with the the company that cooperated with other enterprises or organizations in other innovation activities excluding R&D, and with innovation cooperation partner with a competitor in Portugal, is slowingdown product innovation.

Comparing the values of the significant coefficients of variables A and B for when they are equal to 1 and 2, we can state that the values of the coefficients in general are higher for when the variables are equal to 2 (that is, practice innovation within the company itself and with other companies or organizations), which was aligned with the research expectations, in the view that a company who practices innovation with others besides itself, is expected to presente an higher level of innovation intensity.

Table 9 - Multinomial Probit for all sample for variable A

A	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0	(base outcome)					
1						
A0601	0.725658***	0.144535	5.02	0	0.4423748	1.00894
A0701	-0.19254	0.144428	-1.33	0.183	-0.475609	0.0905386
A0603	0.929919**	0.445371	2.09	0.037	0.0570075	1.802831
B1610	0.526847*	0.296405	1.78	0.075	-0.0540953	1.107789
B1501	1.132013***	0.10455	10.83	0	0.9270982	1.336928
B1502	1.278042***	0.124313	10.28	0	1.034394	1.521691
ccc	0.681166***	0.026414	25.79	0	0.6293958	0.7329351
cccxa0701	0.158703	0.17362	0.91	0.361	-0.1815861	0.4989927
cccxa0603	-0.44326	0.397768	-1.11	0.265	-1.222875	0.3363463
cccxb1610	-0.29571	0.234646	-1.26	0.208	-0.7556095	0.1641868
cccxb1501	-0.13458	0.093202	-1.44	0.149	-0.3172546	0.0480908
cccxb1502	-0.62405***	0.102012	-6.12	0	-0.8239949	-0.424114
_cons	-1.33955	0.020788	-64.44	0	-1.380292	-1.298806
2						
A0601	0.808979***	0.162609	4.97	0	0.4902711	1.127687
A0701	-0.16957	0.199728	-0.85	0.396	-0.5610295	0.22189
A0603	0.499593	0.550635	0.91	0.364	-0.5796327	1.578819

B1610	0.818843***	0.298751	2.74	0.006	0.2333014	1.404384
B1501	1.2723***	0.116501	10.92	0	1.043962	1.500637
B1502	1.869467***	0.129408	14.45	0	1.615831	2.123102
ccc	0.76959***	0.03147	24.45	0	0.7079091	0.8312702
cccxa0701	0.269874	0.199087	1.36	0.175	-0.1203295	0.6600775
cccxa0603	-0.25131	0.448691	-0.56	0.575	-1.130727	0.6281108
cccxb1610	-0.26021	0.229229	-1.14	0.256	-0.7094902	0.1890708
cccxb1501	0.060069	0.097317	0.62	0.537	-0.1306692	0.2508064
cccxb1502	-0.49863***	0.102672	-4.86	0	-0.6998667	-0.297399
_cons	-2.15068	0.029041	-74.06	0	-2.207597	-2.093761

Legend: ***1% significance; **5% significance; *10% significance.

Table 10 - Multinomial Probit for all sample for variable B

B	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0	(base outcome)					
1						
A0601	0.993964***	0.144158	6.89	0	0.7114198	1.276509
A0701	-0.12879	0.156753	-0.82	0.411	-0.4360187	0.17844
A0603	0.326877	0.43204	0.76	0.449	-0.5199064	1.173659
B1610	0.818787***	0.265955	3.08	0.002	0.2975241	1.340049
B1501	0.888801***	0.105163	8.45	0	0.6826849	1.094916
B1502	0.913979***	0.119039	7.68	0	0.6806661	1.147292
ccc	0.803984***	0.026915	29.87	0	0.7512317	0.8567358
cccxa0701	0.124735	0.172269	0.72	0.469	-0.2129053	0.4623753
cccxa0603	-0.26418	0.391462	-0.67	0.5	-1.031437	0.5030677
cccxb1610	-0.59005***	0.209719	-2.81	0.005	-1.00109	-0.179006
cccxb1501	-0.08928	0.092909	-0.96	0.337	-0.2713744	0.0928216
cccxb1502	-0.37423***	0.099665	-3.75	0	-0.5695747	-0.178895
_cons	-1.69566	0.022916	-73.99	0	-1.740577	-1.650748
2						
A0601	1.023445***	0.169503	6.04	0	0.6912253	1.355666
A0701	-0.26694	0.265399	-1.01	0.315	-0.7871109	0.2532331
A0603	0.275976	0.537996	0.51	0.608	-0.7784768	1.330428
B1610	1.043531***	0.26749	3.9	0	0.5192602	1.567801
B1501	1.365654***	0.118745	11.5	0	1.132918	1.59839
B1502	1.385627***	0.129778	10.68	0	1.131267	1.639987
ccc	0.959061***	0.034598	27.72	0	0.8912494	1.026872
cccxa0701	0.033865	0.228846	0.15	0.882	-0.4146647	0.482394
cccxa0603	-0.30718	0.442799	-0.69	0.488	-1.175049	0.5606893
cccxb1610	-0.74337***	0.203738	-3.65	0	-1.142687	-0.344049
cccxb1501	0.120828	0.096806	1.25	0.212	-0.0689083	0.3105646
cccxb1502	-0.19978*	0.102191	-1.95	0.051	-0.4000659	0.0005148
_cons	-2.69397	0.037646	-71.56	0	-2.767752	-2.620182

Legend: ***1% significance; **5% significance; *10% significance.

By observing tables 11 and 12, it is verified that the multilevel poisson model is very similar to the OLS model in terms of the significance levels associated with the variables under analysis. The only difference is with the variable innovation cooperation partner with a competitor in Portugal (B1610) that for process innovation is only significant at 10%, and the company cooperated with other companies or organizations in R&D activities moderated by co-creation (cccxb1501) variable, which unlike the OLS model, is significant in this model. For the case of product innovation we also have a difference between this model and the OLS model, which is the fact that the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) variable is significant in this model.

For process innovation (A), in a similar way of what was observed through the model developed earlier, we can verify that all statistically significant variables representing open innovation, co-opetition and co-creation have a positive influence on variable A. The remaining variables with the moderation of co-creation on the other hand denote negative coefficients. Furthermore, the moderation of co-creation in the relationship between firms cooperating with other firms or organizations in innovation activities excluding R&D and co-innovation restrains process innovation, and also denotes a negative effect on the company that cooperated with other companies or organizations in R&D activities.

In the case of product innovation (B), as in variable A, all significant variables of open innovation, co-creation and co-opetition positively influence product innovation. The remaining variables moderated by co-creation that are significant all denote negative coefficients, in what we can ascertain that co-creation when combined with the company cooperated with other companies or organizations in R&D activities; the company cooperated with other enterprises or organizations in other innovation activities (excluding R&D) and with innovation cooperation partner with a competitor in Portugal is slowingdown product innovation in all cases.

For the total sample, in all three models developed above, we can see that the open innovation variables when moderated by co-creation are not significant for process innovation or product innovation, that is, co-creation when combined with open innovation does not denote a significant influence on co-innovation.

Table 11 - Multilevel poisson for all sample for variable A

A	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
A0601	0.325564***	0.076616	4.25	0	0.175399	0.4757283
A0701	-0.125225	0.1263701	-0.99	0.322	-0.3729059	0.1224558
A0603	0.330937	0.2425837	1.36	0.172	-0.144518	0.8063925
B1610	0.205976*	0.1179971	1.75	0.081	-0.0252939	0.4372461
B1501	0.799012***	0.0670473	11.92	0	0.6676016	0.9304221
B1502	0.950493***	0.0704195	13.5	0	0.8124732	1.088513
ccc	0.573406***	0.0179418	31.96	0	0.5382405	0.608571
cccxa0701	0.126703	0.1033129	1.23	0.22	-0.0757869	0.3291923
cccxa0603	-0.180621	0.1879338	-0.96	0.337	-0.5489641	0.187723
cccxb1610	-0.062602	0.0827148	-0.76	0.449	-0.2247199	0.0995162
cccxb1501	-0.190403***	0.0474762	-4.01	0	-0.2834542	-0.097351
cccxb1502	-0.337632***	0.0496584	-6.8	0	-0.4349604	-0.240303
_cons	-1.372439	0.0192557	-71.27	0	-1.410179	-1.334698

Legend: ***1% significance; **5% significance; *10% significance.

Table 12 - Multilevel poisson for all sample for variable B

B	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
A0601	0.4355143***	0.0791317	5.5	0	0.2804189	0.5906096
A0701	-0.1446795	0.1576417	-0.92	0.359	-0.4536515	0.1642926
A0603	0.3300067	0.2815788	1.17	0.241	-0.2218776	0.881891
B1610	0.3922661***	0.1272283	3.08	0.002	0.1429032	0.641629
B1501	1.036802***	0.0776178	13.36	0	0.8846744	1.188931
B1502	0.8930818***	0.0834033	10.71	0	0.7296142	1.056549
ccc	0.7749777***	0.0200692	38.62	0	0.7356428	0.8143127
cccxa0701	0.0427719	0.1212211	0.35	0.724	-0.1948171	0.2803609
cccxa0603	-0.2438775	0.2075756	-1.17	0.24	-0.6507183	0.1629633
cccxb1610	-0.2403484***	0.0881769	-2.73	0.006	-0.4131719	-0.067525
cccxb1501	-0.2569888***	0.0518841	-4.95	0	-0.3586799	-0.155298
cccxb1502	-0.2957225***	0.0550986	-5.37	0	-0.4037138	-0.187731
_cons	-1.854313	0.0243458	-76.17	0	-1.90203	-1.806596

Legend: ***1% significance; **5% significance; *10% significance.

4.2 – Bioeconomy firms

After analyzing the results obtained for the total sample we will present the results obtained for the Bioeconomy firms, starting with the descriptive statistics, then the

correlations, and finally we will present the three models we developed, which are the OLS model used as the prediction model and two explanatory models, which are the multinomial probit and multilevel poisson.

Through the table 13 we can verify that of the total available sample being worked on only 2592 companies belong to the group of bioeconomy firms, which are based in Portugal. All variables are binary variables, the variables licensed your intellectual property rights to others (A0601); purchased or received licensing of patents or intellectual property rights (A0701); exchanged intellectual property rights (A0603); the company cooperated with other companies or organizations in R&D activities (B1501); the company cooperated with other enterprises or organizations in other innovation activities excluding R&D (B1502) and innovation cooperation partner with a competitor in Portugal (B1610) range between 0 and 1, all other variables vary between 0 and 2. With the observation of the averages of the remaining variables we can conclude that these have many more values with zero than with one, since all the averages of the binary variables are less than 0.5. Regarding the VIF this same serves to test the multicollinearity of the variables, with the represented heats we can say that there is no multicollinearity between them, since all values are less than 10, and the average of these same is less than 5.

Table 13 - Descriptive statistics for bioeconomy firms

Variable	Obs	Mean	Std. Dev.	VIF	1/VIF
A	2,592	0.419753	0.667752		
B	2,592	0.354553	0.625943		
A0601	2,592	0.011574	0.106979	1.04	0.962382
A0701	2,592	0.02392	0.152829	1.34	0.746691
A0603	2,592	0.003086	0.055481	1.03	0.974369
B1610	2,592	0.011574	0.106979	2.43	0.411973
B1501	2,592	0.087963	0.283296	3.11	0.32931
B1502	2,592	0.055941	0.229853	3.17	0.315355
ccc	2,592	0.395448	0.7423	1.31	0.765431
cccxa0701	2,592	0.010803	0.138495	1.37	0.729429
cccxb1501	2,592	0.088735	0.393694	3.58	0.279275
cccxb1502	2,592	0.060571	0.331942	3.54	0.282729
cccxb1610	2,592	0.01196	0.150426	2.46	0.405844

Correlation means mutual relationship between two terms. To correlate, therefore, means to establish a relationship. Thus, the linear correlation method is used to study the joint behavior of two quantitative variables.

Looking at tables 14 and 15, we can see that the correlation levels between the variables undergo some changes with the change in the dependent variable in question. Although

there are some relatively high values, as is the case of the correlation relations between variables (A0603) - exchanged intellectual property rights moderated by co-creation (cccxa0603); the company cooperated with other companies or organizations in R&D activities (B1501) - the company cooperated with other companies or organizations in R&D activities moderated by co-creation (cccxb1501); the company cooperated with other enterprises or organizations in other innovation activities excluding R&D (B1502) - the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) and innovation cooperation partner with a competitor in Portugal (B1610) - innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610) for both dependent variables, these do not present any problem for the models to be developed, since all these values are below 0.75.

Table 14 - Correlation of A for bioeconomy firms

	A	**A0601**	**A0701**	**A0603**	**B1610**	**B1501**	**B1502**	**ccc**	**cccxa0701**	**cccxb1501**	**cccxb1502**	**cccxb1610**
A	1											
A0601	0.1319	1										
A0701	0.0377	0.0067	1									
A0603	0.0692	0.124	-0.0087	1								
B1610	0.1643	0.0557	-0.0169	0.059	1							
B1501	0.4188	0.1192	0.0227	0.0809	0.2975	1						
B1502	0.3574	0.0835	-0.0051	0.047	0.2405	0.523	1					
ccc	0.4016	0.0347	0.0118	0.0266	0.093	0.2566	0.2254	1				
cccxa0701	0.0762	-0.0084	0.4984	-0.00043	-0.0084	0.0446	0.0053	0.1461	1			
cccxb1501	0.3574	0.0489	0.0096	0.0405	0.223	0.7259	0.4185	0.4372	0.0744	1		
cccxb1502	0.2875	0.0129	-0.0134	0.0318	0.1976	0.3989	0.7498	0.3648	0.0193	0.582	1	
cccxb1610	0.1421	-0.0086	-0.0124	-0.00044	0.7349	0.2198	0.2039	0.1616	-0.0062	0.3144	0.2792	1

Table 15 - Correlation of B for bioeconomy firms

	B	**A0601**	**A0701**	**A0603**	**B1610**	**B1501**	**B1502**	**ccc**	**cccxa0701**	**cccxb1501**	**cccxb1502**	**cccxb1610**
B	1											
A0601	0.1174	1										

A0701	0.0001	0.0067	1									
A0603	0.0907	0.124	-0.0087	1								
B1610	0.1404	0.0557	-0.0169	0.059	1							
B1501	0.4204	0.1192	0.0227	0.0809	0.2975	1						
B1502	0.3289	0.0835	-0.0051	0.047	0.2405	0.523	1					
ccc	0.4798	0.0347	0.0118	0.0266	0.093	0.2566	0.2254	1				
cccxa0701	0.0404	-0.0084	0.4984	-0.0043	-0.0084	0.0446	0.0053	0.1461	1			
cccxb1501	0.4204	0.0489	0.0096	0.0405	0.223	0.7259	0.4185	0.4372	0.0744	1		
cccxb1502	0.3275	0.0129	-0.0134	0.0318	0.1976	0.3989	0.7498	0.3648	0.0193	0.582	1	
cccxb1610	0.1271	-0.0086	-0.0124	-0.0044	0.7349	0.2198	0.2039	0.1616	-0.0062	0.3144	0.2792	1

By observing table 16 and 17 referring to the OLS model for the dependent variable A and B respectively, we can verify some differences for the OLS model developed for the total sample, unlike the total sample, it is expected through the analysis of table 15 that for process innovation the innovation cooperation partner with a competitor in Portugal (B1610) is not significant in the models to be developed. For product innovation (B), considerable differences can also be noted when compared to the ols model of the total sample, it is expected that innovation cooperation partner with a competitor in Portugal (B1610) and innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610) are not significant, on the other hand, the variables Exchanged intellectual property rights (A0603) and purchased or received licensing of patents or intellectual property rights moderated by co-creation (cccx0701) that previously did not present a degree of significance, which holds in this last model estimation.

One more difference that can be observed in the two tables presented below is that for bioeconomy firms the variables show higher coefficient for process innovation (A), comparing to what happened in the OLS regressions of the total sample.

One more difference that can be observed in the two tables presented below is that for bioeconomy firms the variables show higher coefficient for process innovation (A), comparing to what happened in the OLS regressions of the total sample.

Table 16 - OLS regression for bioeconomy firms for A

A	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
A0601	0.441616***	0.105076	4.2	0	0.2355743	0.6476571
A0701	0.104786	0.083503	1.25	0.21	-0.0589527	0.2685252
A0603	0.289958	0.20136	1.44	0.15	-0.1048861	0.684802
B1610	0.105066	0.160599	0.65	0.513	-0.20985	0.419981
B1501	0.602259***	0.068605	8.78	0	0.4677333	0.7367847
B1502	0.613057***	0.085433	7.18	0	0.4455324	0.780581
ccc	0.287958***	0.01698	16.96	0	0.2546616	0.321254
cccxa0701	0.042588	0.093229	0.46	0.648	-0.1402231	0.2253986
cccxb1610	0.043294	0.115073	0.38	0.707	-0.1823504	0.2689382
cccxb1501	-0.03079	0.053003	-0.58	0.561	-0.1347241	0.0731419
cccxb1502	-0.17392***	0.062478	-2.78	0.005	-0.2964311	-0.051406
_cons	0.221169	0.012996	17.02	0	0.1956866	0.246652

Legend: ***1% significance; **5% significance; *10% significance.

Table 17 - OLS regression for bioeconomy firms for variable B

B	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
A0601	0.343143***	0.095348	3.6	0	0.1561754	0.5301095
A0701	0.027373	0.075772	0.36	0.718	-0.1212074	0.1759541
A0603	0.527568***	0.182719	2.89	0.004	0.1692764	0.8858588
B1610	0.144147	0.145731	0.99	0.323	-0.1416153	0.4299087
B1501	0.487184***	0.062254	7.83	0	0.3651117	0.6092555
B1502	0.280339***	0.077524	3.62	0	0.1283231	0.4323545
ccc	0.322345***	0.015408	20.92	0	0.2921315	0.3525591
cccxa0701	-0.147852*	0.084598	-1.75	0.081	-0.3137388	0.0180353
cccxb1610	-0.158327	0.10442	-1.52	0.13	-0.3630825	0.0464278
cccxb1501	0.092394*	0.048096	1.92	0.055	-0.0019177	0.1867049
cccxb1502	-0.012506	0.056694	-0.22	0.825	-0.123677	0.0986644
_cons	0.156672	0.011792	13.29	0	0.1335483	0.1797956

Legend: ***1% significance; **5% significance; *10% significance.

Tables 18 and 19 represent the multinomial probit model for variables A and B respectively for the bioeconomy firms. This model is divided into two levels, one for when the dependent variable equals 1 and another for when the variable equals 2. When the variable is equal to 1 it means that the company practices process/product innovation within the company itself or with other companies or organizations, when the variable is equal to 2 it means that the company in question simultaneously practices innovation within the company itself and with other companies or organizations.

With regard to the coefficients and their significance, we can see that they are identical to those presented in the OLS model however for variable A we can verify that contrary to what was presented in the previous model the variable Exchanged intellectual property rights (A0603) is significant for both levels of process innovation, and the innovation cooperation partner with a competitor in Portugal (B1610) that before was not significant, presents in this model a significance at 5% for when A=1. For product innovation there are two remarkable differences, the purchased or received licensing of patents or intellectual property rights moderated by co-creation (cccx0701) and the company cooperated with other companies or organizations in R&D activities moderated by co-creation (cccxb1501) are no longer significant for the two levels of variable B.

Through the analysis of table 18 we can verify that for process innovation (A) for both levels, all significant independent variables positively influence process innovation, with the exception of variable innovation cooperation partner with a competitor in Portugal (B1610) which negatively influences variable A when it equals one, however the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) is significant and negatively influences process innovation. In other words, the moderation of co-creation in the relationship between firms cooperating with other firms or organizations in innovation activities excluding R&D and co-innovation is slowingdown process innovation.

For product innovation (B) we can notice some differences, for both levels of B unlike what was seen in the previous OLS model the purchased or received licensing of patents or intellectual property rights moderated by co-creation (cccxa0701) and the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) are no longer significant. As in process innovation, all the significant independent variables are positively influencing product innovation, and for this model the variables moderated by co-creation have no influence on product innovation since none of them are significant for any level of the B variable.

Comparing the values of the significant coefficients of variables A and B for when they are equal to 1 and 2, we can state that the values of the coefficients in general are higher for when the variables are equal to 2 (practice innovation within the company itself and with other companies or organizations), which was to be expected, since a company

that practices innovation with others besides itself is normal to present higher levels of innovation intensity.

Table 18 - Multinomial Probit for bioeconomy firms for variable A

A	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0	(base outcome)					
1						
A0601	1.190223***	0.4301813	2.77	0.006	0.3470835	2.033363
A0701	0.188762	0.3041583	0.62	0.535	-0.407377	0.7849017
A0603	1.756622*	0.9472688	1.85	0.064	-0.0999903	3.613235
B1610	-1.72454**	0.7644949	-2.26	0.024	-3.22292	-0.226155
B1501	1.62713***	0.2396448	6.79	0	1.157435	2.096825
B1502	1.113843***	0.3266112	3.41	0.001	0.4736967	1.753989
ccc	0.729951***	0.0576773	12.66	0	0.6169055	0.8429963
cccxa0701	0.038863	0.3323051	0.12	0.907	-0.6124431	0.690169
cccxb1610	0.4562	0.5392729	0.85	0.398	-0.6007559	1.513155
cccxb1501	-0.24152	0.2045132	-1.18	0.238	-0.6423556	0.1593216
cccxb1502	-0.57409***	0.2469569	-2.32	0.02	-1.058112	-0.090059
_cons	-1.38992	0.0493576	-28.16	0	-1.486662	-1.293184
2						
A0601	1.677416***	0.4516046	3.71	0	0.7922873	2.562545
A0701	0.454717	0.3855002	1.18	0.238	-0.3008491	1.210284
A0603	1.604045*	0.9719374	1.65	0.099	-0.3009171	3.509007
B1610	0.138975	0.5771317	0.24	0.81	-0.9921823	1.270132
B1501	1.819981***	0.262434	6.94	0	1.30562	2.334342
B1502	1.923618***	0.3339569	5.76	0	1.269074	2.578161
ccc	0.887102***	0.0698982	12.69	0	0.7501043	1.0241
cccxa0701	0.012652	0.3699571	0.03	0.973	-0.7124509	0.7377545
cccxb1610	0.038316	0.4461299	0.09	0.932	-0.836083	0.9127141
cccxb1501	-0.07676	0.2124791	-0.36	0.718	-0.4932127	0.3396899
cccxb1502	-0.58903**	0.24581	-2.4	0.017	-1.070805	-0.107247
_cons	-2.30997	0.0731876	-31.56	0	-2.453418	-2.166527

Legend: ***1% significance; **5% significance; *10% significance.

Table 19 - Multinomial Probit for bioeconomy firms for variable B

B	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0	(base outcome)					
1						
A0601	0.9931037**	0.3886984	2.55	0.011	0.2312688	1.754939
A0701	0.223539	0.3099906	0.72	0.471	-0.3840315	0.8311095
A0603	1.707621*	0.945996	1.81	0.071	-0.1464974	3.561739
B1610	-0.5085997	0.6418582	-0.79	0.428	-1.766619	0.7494191
B1501	0.9277195***	0.237563	3.91	0	0.4621047	1.393334

B1502	0.6804067**	0.2954584	2.3	0.021	0.1013188	1.259495
ccc	0.8998632***	0.0583148	15.43	0	0.7855682	1.014158
cccxa0701	0.0237498	0.3147406	0.08	0.94	-0.5931305	0.6406301
cccxb1610	-0.1987501	0.4652672	-0.43	0.669	-1.110657	0.7131568
cccxb1501	-0.1364605	0.2037954	-0.67	0.503	-0.5358922	0.2629711
cccxb1502	-0.2226783	0.2351528	-0.95	0.344	-0.6835692	0.2382127
_cons	-1.608752	0.052274	-30.78	0	-1.711207	-1.506297
2						
A0601	1.203802***	0.4385698	2.74	0.006	0.3442207	2.063383
A0701	-0.1097981	0.5715896	-0.19	0.848	-1.230093	1.010497
A0603	2.202794**	0.9580151	2.3	0.021	0.3251187	4.080469
B1610	0.4508578	0.5806006	0.78	0.437	-0.6870985	1.588814
B1501	1.781147***	0.2667723	6.68	0	1.258283	2.304011
B1502	0.7738519**	0.3374447	2.29	0.022	0.1124725	1.435231
ccc	1.091402***	0.0765823	14.25	0	0.9413033	1.2415
cccxa0701	-0.7649174	0.5829761	-1.31	0.189	-1.90753	0.3776947
cccxb1610	-0.6100527	0.4295141	-1.42	0.156	-1.451885	0.2317795
cccxb1501	0.0733689	0.2153791	0.34	0.733	-0.3487664	0.4955041
cccxb1502	0.0062939	0.2517991	0.02	0.98	-0.4872232	0.499811
_cons	-2.721353	0.0904595	-30.08	0	-2.89865	-2.544055

Legend: ***1% significance; **5% significance; *10% significance.

By observing tables 20 and 21, it is worthwhile to outline that the multilevel poisson model is very similar to the OLS model in terms of the significance detected for the A variable, the only difference is with the company cooperated with other companies or organizations in R&D activities moderated by co-creation (xxxcb1501) that for process innovation (A) did not present significance, but in this model it denotes 1% significance. On the other hand, in product innovation more differences can already be noticed, in the OLS model the exchanged intellectual property rights (A0603) and Purchased or received licensing of patents or intellectual property rights moderated by co-creation (cccxa0701) were significant, which is not the case in this model.

For process innovation (A), similar to what was seen in the model developed earlier, we can see that all variables of open innovation, co-opetition and co-creation that are significant positively influence variable A. Conversely, the remaining variables with the moderation of co-creation reveal to have negative coefficients. Thus, in addition to the moderation of co-creation in the relationship between firms cooperating with other firms or organizations in innovation activities (excluding R&D), co-innovation is slowingdown process innovation and unveiling a negative influence when the company cooperated with other companies or organizations in terms of R&D activities.

In the case of product innovation (B), as in variable A all variables of open innovation, co-creation and co-opetition that are significant, reveal to play a significantly positive influence on product innovation. The remaining variable moderated by co-creation that shows significance denotes a negative coefficient, in which we can see that co-creation when combined with the firm cooperated with other firms or organizations, in terms of R&D activities, is slowingdown product innovation.

For the bioeconomy firms, in all three models developed above, we can see that the open innovation variables when moderated by co-creation are not significant for process innovation or product innovation, that is, co-creation when combined with open innovation does not significantly influence co-innovation.

Table 20 - Multilevel poisson for bioeconomy firms for variable A

A	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
A0601	0.4231283**	0.1771368	2.39	0.017	0.0759466	0.77031
A0701	0.3010205	0.2286547	1.32	0.188	-0.1471344	0.7491754
A0603	0.2555585	0.3299227	0.77	0.439	-0.3910781	0.9021951
B1610	0.1464971	0.2630834	0.56	0.578	-0.3691369	0.6621311
B1501	1.129756***	0.1438225	7.86	0	0.8478691	1.411643
B1502	0.7480139***	0.1631406	4.59	0	0.4282642	1.067764
ccc	0.637495***	0.0396564	16.08	0	0.55977	0.7152201
cccxa0701	-0.055555	0.1833797	-0.3	0.762	-0.4149721	0.3038632
cccxb1610	-0.007479	0.1773757	-0.04	0.966	-0.3551285	0.3401715
cccxb1501	-0.334469***	0.0982773	-3.4	0.001	-0.5270893	-0.141849
cccxb1502	-0.271245**	0.1099238	-2.47	0.014	-0.4866916	-0.055798
_cons	-1.464916	0.0471577	-31.06	0	-1.557343	-1.372489

Legend: ***1% significance; **5% significance; *10% significance.

Table 21 - Multilevel poisson for bioeconomy firms for variable B

B	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
A0601	0.3647609*	0.1959004	1.86	0.063	-0.0191969	0.7487187
A0701	0.1106792	0.2957021	0.37	0.708	-0.4688864	0.6902447
A0603	0.4856738	0.3214801	1.51	0.131	-0.1444156	1.115763
B1610	0.1991582	0.3005688	0.66	0.508	-0.3899458	0.7882622
B1501	1.286366***	0.1615783	7.96	0	0.9696781	1.603053
B1502	0.4995004***	0.1916108	2.61	0.009	0.1239502	0.8750507
ccc	0.8102243***	0.0424822	19.07	0	0.7269607	0.8934878
cccxa0701	-0.2113502	0.2324348	-0.91	0.363	-0.666914	0.2442137
cccxb1610	-0.1565297	0.1976709	-0.79	0.428	-0.5439575	0.2308982
cccxb1501	-0.3662544***	0.1053034	-3.48	0.001	-0.5726454	-0.159864
cccxb1502	-0.1627158	0.1215023	-1.34	0.181	-0.4008559	0.0754244
_cons	-1.796231	0.0555391	-32.34	0	-1.905085	-1.687376

Legend: ***1% significance; **5% significance; *10% significance.

4.3 – Non-bioeconomy firms

Lastly, the results for non-bioeconomy firms will be presented and discussed, starting with the descriptive statistics, then the correlations, and finally we will present the three models estimade, considering the OLS model used as the prediction model and two explanatory models, which are the multinomial probit and multilevel poisson.

By observing the table 22 presented below, we can see that from the 13701 companies available in the total sample, 11109 belong to the group of non-bioeconomy companies, which are based in Portugal. All variables are binary variables, the variables licensed your intellectual property rights to others (A0601); purchased or received licensing of patents or intellectual property rights (A0701); exchanged intellectual property rights (A0603); the company cooperated with other companies or organizations in R&D activities (B1501); the company cooperated with other enterprises or organizations in other innovation activities excluding R&D (B1502) and innovation cooperation partner with a competitor in Portugal (B1610) range between 0 and 1, all other variables vary between 0 and 2. With the observation of the averages of the remaining variables we can conclude that these have many more values with zero than with one, since all the averages of the binary variables are less than 0.5. Regarding the VIF this same serves to test the multicollinearity of the variables, with the represented heats we can say that there is no multicollinearity between them, since all values are less than 10, and the average of these same is less than 5.

Table 22 - Descriptive statistics for non-bioeconomy firms

Variable	Obs	Mean	Std. Dev.	VIF	1/VIF
A	11,109	0.396255	0.650731		
B	11,109	0.291926	0.58198		
A0601	11,109	0.015573	0.123822	1.04	0.960098
A0701	11,109	0.020974	0.143304	1.24	0.806235
A0603	11,109	0.002701	0.051899	1.89	0.530135
B1610	11,109	0.009902	0.099019	2.37	0.421326
B1501	11,109	0.067693	0.251229	2.68	0.373717
B1502	11,109	0.056621	0.231127	2.8	0.357021
ccc	11,109	0.325682	0.682599	1.29	0.77587
cccxa0603	11,109	0.00216	0.061452	1.86	0.536943
cccxa0701	11,109	0.006751	0.105866	1.26	0.790695
cccxb1502	11,109	0.055091	0.313868	3.26	0.30705
cccxb1501	11,109	0.063102	0.334216	3.25	0.307786

Looking at tables 23 and 24, we can see that the correlation levels between the variables undergo some changes with the change in the dependent variable in question. Although

there are some relatively high values, as is the case of the correlation relations between exchanged intellectual property rights (A0603) - exchanged intellectual property rights moderated by co-creation (cccxa0603); the company cooperated with other companies or organizations in R&D activities (B1501) - the company cooperated with other companies or organizations in R&D activities moderated by co-creation (cccxb1501); the company cooperated with other enterprises or organizations in other innovation activities excluding R&D (B1502) - the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) and innovation cooperation partner with a competitor in Portugal (B1610) - innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610) for both dependent variables, these do not present any problem for the models to be developed, since all these values are below 0.75.

Table 23 - Correlation of A for non-bioeconomy firms

	A	**A0601**	**A0701**	**A0603**	**B1610**	**B1501**	**B1502**	**ccc**	**cccxa0603**	**cccxa0701**	**cccxb1502**	**cccxb1501**	**cccxb1610**
A	1												
A0601	0.0899	1											
A0701	-0.0071	0.0019	1										
A0603	0.0376	0.1616	0.0166	1									
B1610	0.1557	0.0241	0.0107	-0.0052	1								
B1501	0.3299	0.0963	0.0156	0.0412	0.3096	1							
B1502	0.3374	0.051	0.0076	0.0548	0.2863	0.5169	1						
ccc	0.3436	0.0838	-0.0008	0.0362	0.0948	0.2394	0.2323	1					
cccxa0603	0.0349	0.0902	0.0153	0.6756	-0.0035	0.0043	0.0421	0.0734	1				
cccxa0701	0.0553	0.0401	0.4357	0.0295	0.0022	0.0505	0.0359	0.1253	0.0531	1			
cccxb1502	0.277	0.052	0.0023	0.0351	0.2055	0.4037	0.7165	0.3902	0.0685	0.043	1		
cccxb1501	0.2965	0.0937	0.01	0.0369	0.2395	0.7007	0.4141	0.417	0.0679	0.0745	0.6045	1	1
cccxb1610	0.125	0.029	-0.0059	-0.0038	0.7215	0.2356	0.207	0.1622	-0.0025	0.0018	0.2989	0.3475	1.0000

Table 24 - Correlation of B for non-bioeconomy firms

	B	A0601	A0701	A0603	B1610	B1501	B1502	ccc	cccxa0603	cccxa0701	cccxb1502	cccxb1501	cccxb1610
B	1												
A0601	0.1181	1											
A0701	-0.0043	0.0019	1										
A0603	0.0275	0.1616	0.0166	1									
B1610	0.1685	0.0241	0.0107	-0.0052	1								
B1501	0.3716	0.0963	0.0156	0.0412	0.3096	1							
B1502	0.3576	0.051	0.0076	0.0548	0.2863	0.5169	1						
ccc	0.409	0.0838	-0.0008	0.0362	0.0948	0.2394	0.2323	1					
cccxa0603	0.0302	0.0902	0.0153	0.6756	-0.0035	0.043	0.0421	0.0734	1				
cccxa0701	0.0586	0.0401	0.4357	0.0295	0.0022	0.0505	0.0359	0.1253	0.0531	1			
cccxb1502	0.3338	0.052	0.0023	0.0351	0.2055	0.4037	0.7165	0.3902	0.0685	0.043	1		
cccxb1501	0.3644	0.0937	0.01	0.0369	0.2395	0.7007	0.4141	0.417	0.0679	0.0745	0.6045	1	
cccxb1610	0.133	0.029	-0.0059	-0.0038	0.7215	0.2356	0.207	0.1622	-0.0025	0.0018	0.2989	0.3475	1

By observing table 25 and 26 referring to the OLS model for the dependent variable A and B respectively, we can find similarities, for all normal independent variables we can see that for both variables it is expected that all of them are significant at 1% in the models to be developed with the exception of variables exchanged intellectual property rights (A0603) that are significant at 10% for process innovation (A) and A0701 that are not significant for both variables. As for the independent variables moderated by co-creation, some differences are already noticed, for variable A it is expected that only the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) is significant in the following models, however for variable B it is already expected that the variables innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610) and the company cooperated with other companies or organizations in R&D activities moderated by co-creation (cccxb1501) are significant.

With regard to the coefficients, you can also see that they have a greater influence on variable B, since all the significant coefficients are higher than those presented in the model for variable A, with the exception of the company cooperated with other

enterprises or organizations in other innovation activities excluding R&D B1502, the company cooperated with other companies or organizations in R&D activities (B1501) and the company cooperated with other enterprises or organizations in other innovation activities moderated by co-creation (cccxb1502).

Table 25 - OLS regression for non-bioeconomy firms for variable A

A	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
A0601	0.2175586***	0.0451483	4.82	0	0.1290599	0.3060574
A0701	-0.079469*	0.0425705	-1.87	0.062	-0.1629143	0.003977
A0603	0.1222453	0.1449598	0.84	0.399	-0.1619017	0.4063923
B1610	0.2585793***	0.0852255	3.03	0.002	0.0915222	0.4256364
B1501	0.3861819***	0.035666	10.83	0	0.3162701	0.4560936
B1502	0.6454005***	0.0396642	16.27	0	0.5676515	0.7231494
ccc	0.2551648***	0.0091104	28.01	0	0.2373069	0.2730228
cccxa0701	0.0833514	0.0581884	1.43	0.152	-0.0307082	0.1974109
cccxa0603	-0.085478	0.1216448	-0.7	0.482	-0.3239231	0.1529678
cccxb1610	-0.081386	0.0637571	-1.28	0.202	-0.2063615	0.043589
cccxb1501	0.036926	0.0295423	1.25	0.211	-0.0209822	0.0948342
cccxb1502	-0.142844***	0.0314952	-4.54	0	-0.2045797	-0.081107
_cons	0.2518012	0.0063015	39.96	0	0.2394492	0.2641531

Legend: ***1% significance; **5% significance; *10% significance.

Table 26 - OLS regression for non-bioeconomy firms for variable A

B	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
A0601	0.3042393***	0.0387244	7.86	0	0.2283325	0.3801461
A0701	-0.047086	0.0365134	-1.29	0.197	-0.1186587	0.0244867
A0603	-0.02696	0.1243344	-0.22	0.828	-0.2706775	0.2167575
B1610	0.4109886***	0.0730993	5.62	0	0.267701	0.5542762
B1501	0.3596593***	0.0305913	11.76	0	0.2996949	0.4196238
B1502	0.4543044***	0.0340207	13.35	0	0.3876178	0.5209909
ccc	0.263106***	0.0078141	33.67	0	0.2477889	0.278423
cccxa0701	0.0275824	0.0499091	0.55	0.581	-0.0702483	0.1254131
cccxa0603	-0.1329295	0.1043367	-1.27	0.203	-0.337448	0.071589
cccxb1610	-0.261614***	0.0546855	-4.78	0	-0.3688073	-0.154421
cccxb1501	0.1027673***	0.0253389	4.06	0	0.0530985	0.1524361
cccxb1502	-0.0244044	0.027014	-0.9	0.366	-0.0773565	0.0285478
_cons	0.1459005	0.0054049	26.99	0	0.135306	0.156495

Legend: ***1% significance; **5% significance; *10% significance.

Tables 27 and 28 represent the multinomial probit model for variables A and B respectively. This model is divided into two levels, one for when the dependent variable

equals 1 and another for when the variable equals 2. When the variable is equal to 1 it means that the company practices process/product innovation within the company itself or with other companies or organizations, when the variable is equal to 2 it means that the company in question simultaneously practices innovation within the company itself and with other companies or organizations.

With regard to the coefficients and their significance, we can see that they are identical to those presented in the OLS model with only one small difference. In the model for variable A, exchanged intellectual property rights (A0603), which was not significant before, becomes significant for 5% when the variable is equal to 1.

Through the analysis of table 27 we can verify that for process innovation (A) for both levels all normal independent variables that are significant influence process Through the analysis of table 27 we can verify that for process innovation (A) for both levels all normal independent variables that are significant influence process innovation positively, with the exception of purchased or received licensing of patents or intellectual property rights (A0701) which negatively influences (this is the only model where this variable is significant) the dependent variable. Nevertheless, the the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) is significant and restrains process innovation. In other words, the moderation of co-creation in the relationship between firms cooperating with other firms or organizations in innovation activities (excluding R&D) and co-innovation is slowingdown process innovation.

For product innovation (B) we can notice some differences, for both levels of B unlike what was seen in the previous OLS model the variable cccxb1501 is no longer significant and the variable cccxb1502 that was not significant became significant for both levels. As in process innovation, all normal independent variables that are significant, positively influence product innovation, however the moderating variables negatively influence it, being the innovation cooperation partner with a competitor in Portugal moderated by co-creation (cccxb1610) and the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502), this means that co-creation combined with the company cooperated with other enterprises or organizations in other innovation activities (excluding R&D) and with innovation cooperation partner with a competitor in Portugal negatively is slowingdown product innovation.

Comparing the values of the significant coefficients of variables A and B for when they are equal to 1 and 2, we can state that the values of the coefficients in general are higher

for when the variables are equal to 2 (practice innovation within the company itself and with other companies or organizations), which was an expected result, since a company that practices innovation with others besides itself is normal to present higher levels of innovation intensity.

Table 27 - Multinomial Probit for non-bioeconomy firms for variable A

A	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0	(base outcome)					
1						
A0601	0.6902068***	0.1546159	4.46	0	0.3871652	0.9932483
A0701	-0.3065856*	0.165682	-1.85	0.064	-0.6313163	0.0181451
A0603	0.9365498**	0.4750095	1.97	0.049	0.0055483	1.867551
B1610	1.080497***	0.3650164	2.96	0.003	0.3650777	1.795916
B1501	1.026704***	0.1172315	8.76	0	0.796934	1.256473
B1502	1.294955***	0.1357994	9.54	0	1.028793	1.561117
ccc	0.6695621***	0.0297565	22.5	0	0.6112405	0.7278837
cccxa0701	0.1781834	0.2049154	0.87	0.385	-0.2234434	0.5798103
cccxa0603	-0.6228516	0.4117926	-1.51	0.13	-1.42995	0.1842471
cccxb1610	-0.4846106	0.2794917	-1.73	0.083	-1.032404	0.0631831
cccxb1501	-0.1303354	0.1055103	-1.24	0.217	-0.3371318	0.0764611
cccxb1502	-0.6125962***	0.1130262	-5.42	0	-0.8341235	-0.391069
_cons	-1.329239	0.0229301	-57.97	0	-1.374181	-1.284297
2						
A0601	0.6808714***	0.1776627	3.83	0	0.332659	1.029084
A0701	-0.3713797	0.2406326	-1.54	0.123	-0.8430108	0.1002515
A0603	0.1015236	0.6703685	0.15	0.88	-1.212375	1.415422
B1610	1.126788***	0.3712541	3.04	0.002	0.399143	1.854432
B1501	1.134658***	0.1311832	8.65	0	0.8775435	1.391772
B1502	1.866925***	0.1415266	13.19	0	1.589538	2.144312
ccc	0.7427715***	0.0353984	20.98	0	0.6733919	0.812151
cccxa0701	0.3456823	0.2389454	1.45	0.148	-0.122642	0.8140066
cccxa0603	-0.1426887	0.4940904	-0.29	0.773	-1.111088	0.8257106
cccxb1610	-0.4086674	0.2760338	-1.48	0.139	-0.9496837	0.1323489
cccxb1501	0.0841104	0.1102382	0.76	0.445	-0.1319525	0.3001733
cccxb1502	-0.4690544***	0.1139665	-4.12	0	-0.6924247	-0.245684
_cons	-2.118922	0.0316874	-66.87	0	-2.181028	-2.056816

Legend: ***1% significance; **5% significance; *10% significance.

Table 28 - Multinomial Probit for non-bioeconomy firms for variable B

B	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0	(base outcome)					
1						
A0601	1.038751***	0.1559977	6.66	0	0.7330008	1.3445

A0701	-0.2496775	0.1842567	-1.36	0.175	-0.610814	0.1114589
A0603	0.1465664	0.4720403	0.31	0.756	-0.7786156	1.071748
B1610	1.140724***	0.3070321	3.72	0	0.5389518	1.742496
B1501	0.8807995***	0.1180989	7.46	0	0.6493299	1.112269
B1502	0.9511648***	0.1311356	7.25	0	0.6941438	1.208186
ccc	0.7744355***	0.0304195	25.46	0	0.7148144	0.8340565
cccxa0701	0.1170205	0.2102895	0.56	0.578	-0.2951394	0.5291804
cccxa0603	-0.2843471	0.4078696	-0.7	0.486	-1.083757	0.5150627
cccxb1610	-0.6901072***	0.2417859	-2.85	0.004	-1.163999	-0.216216
cccxb1501	-0.0748124	0.1052901	-0.71	0.477	-0.2811772	0.1315524
cccxb1502	-0.3917755***	0.1110374	-3.53	0	-0.6094048	-0.174146
_cons	-1.715973	0.0255107	-67.26	0	-1.765973	-1.665973
2						
A0601	1.043524***	0.1852306	5.63	0	0.6804792	1.40657
A0701	-0.2990069	0.2998749	-1	0.319	-0.8867508	0.2887371
A0603	-0.3339762	0.6933153	-0.48	0.63	-1.692849	1.024897
B1610	1.196785***	0.3102208	3.86	0	0.5887637	1.804807
B1501	1.268889***	0.134087	9.46	0	1.006083	1.531694
B1502	1.498255***	0.1419854	10.55	0	1.219969	1.776541
ccc	0.9229098***	0.039002	23.66	0	0.8464672	0.9993523
cccxa0701	0.2000399	0.2607836	0.77	0.443	-0.3110865	0.7111662
cccxa0603	-0.3079767	0.5139533	-0.6	0.549	-1.315307	0.6993532
cccxb1610	-0.7813114***	0.2355453	-3.32	0.001	-1.242972	-0.319651
cccxb1501	0.117715	0.1097016	1.07	0.283	-0.0972962	0.3327261
cccxb1502	-0.2131218*	0.1130061	-1.89	0.059	-0.4346097	0.0083661
_cons	-2.691825	0.0415357	-64.81	0	-2.773233	-2.610416

Legend: ***1% significance; **5% significance; *10% significance.

By observing tables 29 and 30 we can see that the multilevel poisson model is very similar to the OLS model in the significance of the variables under analysis, the only difference is relatyive to innovation cooperation partner with a competitor in Portugal (B1610) that for process innovation is only significant at 10% and the cccxb1501 variable, which unlike the OLS model, is significant now. For the case of product innovation we also have a difference between this model and the OLS model, which is the fact that the company cooperated with other enterprises or organizations in other innovation activities excluding R&D moderated by co-creation (cccxb1502) variable is now statiscally significant.

For process innovation (A), similar to what was seen in the model developed earlier, we can see that nearly all variables of open innovation, co-opetition and co-creation that are significant, positively influence variable A, with the exception of Purchased or received licensing of patents or intellectual property rights (A0701). The remaining variables with the moderation of co-creation on the other hand present negative

coefficients. In this model, in addition to the moderation of co-creation in the relationship between firms cooperating with other firms or organizations in innovation activities excluding R&D and co-innovation is slowingdown process innovation. It also presents a negative influence for the company that cooperated with other companies or organizations in R&D activities.

In the case of product innovation (B), as in variable A, all variables of open innovation, co-creation and co-opetition that are significant, positively influence product innovation. The remaining variables moderated by co-creation that are significant all present negative coefficients, in what we can ascertain that co-creation when combined with the company cooperated with other companies or organizations in R&D activities; the company cooperated with other enterprises or organizations in other innovation activities (excluding R&D) and with innovation cooperation partner with a competitor in Portugal restrain product innovation in all cases.

For the non-bioeconomy firms, in all three models developed, we can see that the open innovation variables when moderated by co-creation are not significant for process innovation or product innovation, that is, co-creation when combined with open innovation does not have a significant influence on co-innovation. In addition, for non-bioeconomy firms purchased or received licensing of patents or intellectual property rights (A0701) became significant for the first time, meaning that purchased or received licensing of patents or intellectual property rights in non-bioeconomy firms negatively influences process innovation activities.

Table 29 - Multilevel poisson for non-bioeconomy firms for variable A

A	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
A0601	0.3041099***	0.0857083	3.55	0	0.1361248	0.472095
A0701	-0.273623*	0.1519045	-1.8	0.072	-0.5713504	0.0241044
A0603	0.2690513	0.2898499	0.93	0.353	-0.2990441	0.8371467
B1610	0.2227273*	0.1327069	1.68	0.093	-0.0373733	0.482828
B1501	0.7123131***	0.075969	9.38	0	0.5634165	0.8612096
B1502	0.9939673***	0.0780732	12.73	0	0.8409466	1.146988
ccc	0.5581739***	0.0202041	27.63	0	0.5185746	0.5977732
cccxa0701	0.1926095	0.124899	1.54	0.123	-0.0521879	0.437407
cccxa0603	-0.162456	0.2163445	-0.75	0.453	-0.5864828	0.2615719
cccxb1610	-0.076283	0.0939748	-0.81	0.417	-0.2604707	0.1079039
cccxb1501	-0.157278***	0.0543998	-2.89	0.004	-0.2638994	-0.050656
cccxb1502	-0.346013***	0.0558015	-6.2	0	-0.4553819	-0.236644
_cons	-1.353182	0.0211074	-64.11	0	-1.394552	-1.311813

Legend: ***1% significance; **5% significance; *10% significance.

Table 30 - Multilevel poisson for non-bioeconomy firms for variable B

B	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
A0601	0.4638526***	0.0872846	5.31	0	0.2927779	0.6349273
A0701	-0.2385011	0.1869613	-1.28	0.202	-0.6049386	0.1279363
A0603	0.1036333	0.3651952	0.28	0.777	-0.6121362	0.8194029
B1610	0.4170531***	0.1414523	2.95	0.003	0.1398116	0.6942946
B1501	0.9659759***	0.0882648	10.94	0	0.7929801	1.138972
B1502	0.9924922***	0.0928792	10.69	0	0.8104523	1.174532
ccc	0.7616789***	0.0228621	33.32	0	0.7168701	0.8064877
cccxa0701	0.1341432	0.1428711	0.94	0.348	-0.1458791	0.4141655
cccxa0603	-0.2095657	0.2595447	-0.81	0.419	-0.7182639	0.2991326
cccxb1610	-0.2451302**	0.099255	-2.47	0.014	-0.4396665	-0.050594
cccxb1501	-0.2346701***	0.0596729	-3.93	0	-0.3516268	-0.117714
cccxb1502	-0.3217303***	0.0621517	-5.18	0	-0.4435453	-0.199915
_cons	-1.868751	0.0271165	-68.92	0	-1.921898	-1.815604

Legend: ***1% significance; **5% significance; *10% significance.

5 - Conclusion

In this dissertation we had the objective of studying the influence of open innovation, coopetition, and co-creation on co-innovation. The main differentiator is the In this dissertation we had the objective of studying the influence of open innovation, coopetition, and co-creation on co-innovation. The main differentiator is the assessment of the hypothetical moderator role played by co-creation, in terms of the relationships between the open innovation and co-innovation, as well as between coopetition and co-innovation.

Initially we started by presenting a literature review where it is visible how and when the concept of open innovation was created and how it evolved until today, later we explained each of the other variables individually, deriving the four research hypotheses directly from the relevant literature.

In order to address the referred four research hypotheses, three databases were built from the CIS 2018, where we selected three variables for open innovation and coopetition, and two variables to build the co-creation variable that served as a moderator variable; and for co-innovation that represents the response variable. For being able to explain our dependent variables we developed three models, the OLS model which is not a model capable of explaining the variables under study, it is only used as a predictive model, so that we can know the expected value of the coefficients as well as their significance, after that we developed two explanatory models: multinomial probit and multilevel poisson; targeted to the explanation of the response variable: co-innovation.

Bearing in mind the results obtained, we can verify that, for the total sample, all significant variables of open innovation (licensed your intellectual property rights to others) co-opetition (the company cooperated with other companies or organizations in R&D activities, the company cooperated with other enterprises or organizations in other innovation activities excluding R&D and innovation cooperation partner with a competitor in Portugal) and co-creation (ccc) positively influence the co-innovations, in the case of variables moderated by co-creation, these same variables always negatively influence both product innovation and process innovation.

For the bioeconomy firms, the results are slightly distintc, innovation cooperation partner with a competitor in Portugal (B1610) belonging to the group of variables of co-opetition, negatively influences process innovation and does not reveal to be

statistically significant for product innovation and contrary to what is verified for the other two databases, exchanged intellectual property rights (A0603) presents significance for both types of innovation in the multinomial probit model, the variables moderated by co-creation as in the other two databases whenever they are significant, restrain the dependent variables.

In the case of non-bioeconomy firms the variable purchased or received licensing of patents or intellectual property rights (A0701), presents itself for the first time significant for process innovation, denoting a negative influence. All other variables belonging to open innovation, co-opetition, and co-creation present positive coefficients for both dependent variables for the two models developed, however, i tis worthwhile to outline that the variables moderated by co-creation for all databases, are slowingdown co-innovation (including both types of innovation), when it is detected statistical significance.

The econometric models estimated have some limitations, in the view that the variables of open innovation when moderated by co-creation never revealed to be statiscally significant for any model concerning any dependent variable under study. In addition to the purchased or received licensing of patents or intellectual property rights (A0701) and exchanged intellectual property rights (A0603) belonging to open innovation, do not show statistical significance for any of the multilevel poisson models estimated for any database. Another limitation is the fact that none of the models estimated, had the variable Licensed your intellectual property rights to others (A0601) moderated by co-creation because the models did not converge with this variable present in the model, moreover in the models made for bioeconomy firms it was not possible to use the exchanged intellectual property rights moderated by co-creation (cccxA0603) for the same reason.

In terms of implications, based on the set of new empirical evidence now presented, it is recommended that companies that intend to develop process and/or product innovation should not combine co-creation with any other innovation process, since all these combinations slowdown the development of these innovations.

Furthermore, it is recommended the creation of formal programes targeted to the use of exchanged intellectual property rights for co-innovation purposes in bioeconomy firms. For its turn, in non-bioeconomy firms targeted to process co-innovation, the inflows of received licensing of patents or intellectual property rights should be fostered, thorugh new collaborative programes, at the policy level, with fiscal incentives, if it is feasible.

To develop product or process co-innovation in bioeconomy firms, it is advised that firms use only co-creation as an independent process capable of creating innovation, since, co-creation as a moderating variable slows down the creation of both product and process co-innovation.

For future research it is suggested to analyze the relationships among open innovation, co-opetition, and co-innovation, taking as focus the role played by services co-creation in fostering the eco-innovative performance of servitized manufacturing industries.

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Appendix

Table 31 - Significance of the OLS model for all databases

Ols regression		A0601	A0603	A0701	B1501	B1502	B1610	ccc	cccxA0603	cccxA0701	cccxB1501	cccxB1502	cccxB1610
Total sample	A	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	NS
	B	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	(+)	NS	(-)
Bioeconomy firms	A	(+)	NS	NS	(+)	(+)	NS	(+)	DNE	NS	NS	(-)	NS
	B	(+)	(+)	NS	(+)	(+)	NS	(+)	DNE	(-)	(+)	NS	NS
Non-bioeconomy firms	A	(+)	NS	(-)	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	NS
	B	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	(+)	NS	(-)

Legend: (+) positive significance; (-) negative significance; NS not significant; DNE the variable does not exist in the model.

Table 32 - Significance of the Multinomial Probit model for all databases

Multinomial Probit		A0601	A0603	A0701	B1501	B1502	B1610	ccc	cccxA0603	cccxA0701	cccxB1501	cccxB1502	cccxB1610
Total sample	A=1	(+)	(+)	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	NS
	A=2	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	NS
	B=1	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	(-)
	B=2	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	(-)
Bioeconomy firms	A=1	(+)	(+)	NS	(+)	(+)	(-)	(+)	DNE	NS	NS	(-)	NS
	A=2	(+)	(+)	NS	(+)	(+)	NS	(+)	DNE	NS	NS	(-)	NS
	B=1	(+)	(+)	NS	(+)	(+)	NS	(+)	DNE	NS	NS	NS	NS
	B=2	(+)	(+)	NS	(+)	(+)	NS	(+)	DNE	NS	NS	NS	NS
Non-bioeconomy firms	A=1	(+)	(+)	(-)	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	NS

	A=2	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	NS
	B=1	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)	NS
	B=2	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	NS	(-)6	NS

Legend: (+) positive significance; (-) negative significance; NS not significant; DNE the variable does not exist in the model.

Table 33 - Significance of the Multilevel Poisson model for all databases

Multilevel Poisson		A0601	A0603	A0701	B1501	B1502	B1610	ccc	cccxA0603	cccxA0701	cccxB1501	cccxB1502	cccxB1610
Total sample	A	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	(-)	(-)	NS
	B	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	(-)	(-)	(-)
Bioeconomy firms	A	(+)	NS	NS	(+)	(+)	NS	(+)	DNE	NS	(-)	(-)	NS
	B	(+)	NS	NS	(+)	(+)	NS	(+)	DNE	NS	(-)	NS	NS
Non-bioeconomy firms	A	(+)	NS	(-)	(+)	(+)	(+)	(+)	NS	NS	(-)	(-)	NS
	B	(+)	NS	NS	(+)	(+)	(+)	(+)	NS	NS	(-)	(-)	(-)

Legend: (+) positive significance; (-) negative significance; NS not significant; DNE the variable does not exist in the model.