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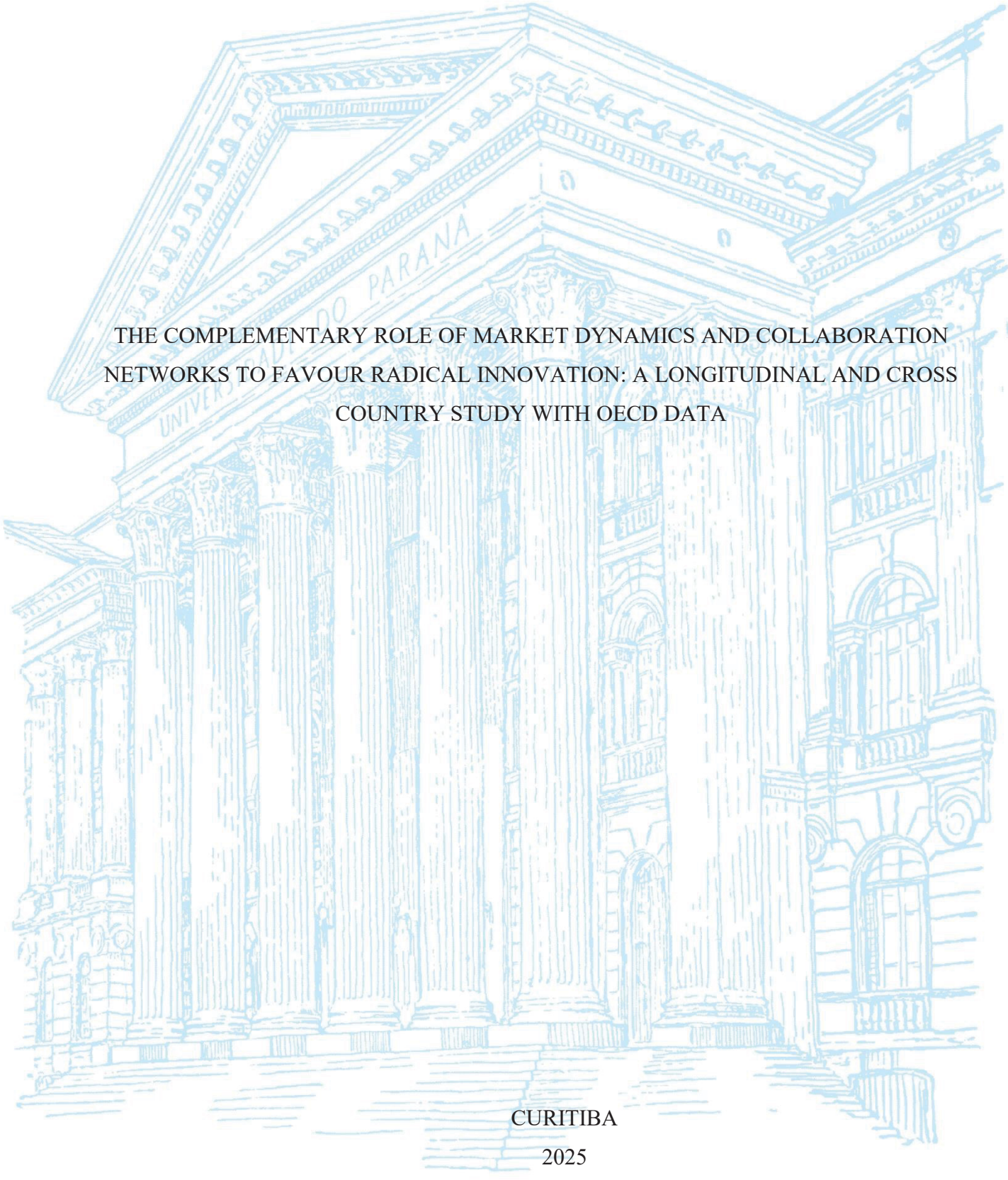

THE COMPLEMENTARY ROLE OF MARKET DYNAMICS AND COLLABORATION NETWORKS TO FAVOUR RADICAL INNOVATION: A LONGITUDINAL AND CROSS COUNTRY STUDY WITH OECD DATA

CURITIBA

2025

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THE COMPLEMENTARY ROLE OF MARKET DYNAMICS AND COLLABORATION NETWORKS TO FAVOUR RADICAL INNOVATION: A LONGITUDINAL AND CROSS COUNTRY STUDY WITH OECD DATA

Tese apresentada ao curso de Pós-Graduação em Administração, Setor de Ciências Sociais Aplicadas, Universidade Federal do Paraná, como requisito parcial à obtenção do título de Doutor em Administração.

Orientadora: Profa. Dra. Simone Regina Didonet

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Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação ADMINISTRAÇÃO da Universidade Federal do Paraná foram convocados para realizar a arguição da tese de Doutorado de **BRUNA CESCATTO COSTA**, intitulada: **The complementary role of market dynamics and collaboration networks to favour radical innovation: a longitudinal and cross country study with OECD data**, sob orientação da Profa. Dra. SIMONE REGINA DIDONET, que após terem inquirido a aluna e realizada a avaliação do trabalho, são de parecer pela sua APROVAÇÃO no rito de defesa.

A outorga do título de doutora está sujeita à homologação pelo colegiado, ao atendimento de todas as indicações e correções solicitadas pela banca e ao pleno atendimento das demandas regimentais do Programa de Pós-Graduação.

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“Para cada coisa há seu momento e um tempo para toda atividade debaixo do céu: Há um tempo para nascer e um tempo para morrer, um tempo para plantar, e um tempo para arrancar as plantas.” (Bíblia de Aparecida, Eclesiastes, 3: 1-2, p.767)

RESUMO

Este estudo busca explorar o papel complementar das dinâmicas de mercado e das redes de colaboração no favorecimento da inovação radical, a qual é um fator-chave para a vantagem competitiva, a transformação do mercado e o crescimento econômico – todas preocupações do campo do marketing estratégico. As dinâmicas de mercado, caracterizadas pela intensidade competitiva e pela turbulência tecnológica, cria tanto oportunidades quanto pressões para as empresas, impulsionando-as a se diferenciar e se adaptar. Enquanto isso, as redes de colaboração – que envolvem atividades de colaboração com fornecedores, clientes, instituições de ensino superior e órgãos governamentais – oferecem recursos e conhecimentos essenciais para navegar em cenários complexos de inovação. Com base na Teoria Evolucionária da Inovação e na perspectiva de Formação de Mercado (Market-Shaping), esta pesquisa assume as empresas como participantes ativas em sistemas de mercado multiníveis e dinâmicos. Utilizando dados quantitativos secundários em painel (2013, 2015, 2017, 2019) de 39 países da Organização para a Cooperação e Desenvolvimento Econômico (OCDE), o estudo examina por meio de regressões hierárquicas como a interação entre as dinâmicas de mercado e as redes de colaboração impacta a inovação radical. Os resultados demonstram que os elementos que mais influenciam na inovação radical são a turbulência tecnológica e a cooperação com clientes. Ainda, comprovam dinâmicas de mercado e redes de colaboração são complementares e precisam ser analisadas em conjunto quando empresas desejam implementar inovações radicais. Esses resultados contribuem teoricamente ao: i) integrar essas duas perspectivas, isso é, a Teoria Evolucionária da Inovação e a perspectiva de Formação de Mercado (Market-Shaping), demonstrando empiricamente seu efeito combinado na inovação radical; ii) fornecer evidências da interação entre dois diferentes níveis do mercado. Além disso, as implicações gerenciais ressaltam a necessidade de as empresas enxergarem a concorrência e a turbulência tecnológica como catalisadores, e não como ameaças, enquanto gerenciam estrategicamente suas redes de colaboração para aprimorar os resultados da inovação. Ao unir contribuições teóricas e práticas, este estudo oferece insights aplicáveis sobre como as empresas podem navegar e influenciar ambientes de mercado complexos para fomentar a inovação radical.

Palavras-chave: Dinâmicas de mercado, Redes de colaboração, Inovação radical, Marketing estratégico, Dados secundários.

ABSTRACT

This study aims to explore the complementarity role of market dynamics and collaboration networks to favour radical innovation, which is a key driver of competitive advantage, market transformation and economic growth – all strategic marketing field concerns. Market dynamics, characterized by competitive intensity and technological turbulence, create both opportunities and pressures for firms, pushing them to differentiate and adapt. Meanwhile, collaboration networks—comprising interactions with suppliers, clients, higher education, and government institutions—offer critical resources and knowledge to navigate complex innovation landscapes. Despite extensive research on these elements individually, their synergistic impact on radical innovation remains underexplored. Grounded in the Evolutionary Theory of Innovation and Market-Shaping perspectives, this research conceptualizes firms as active participants in multi-layered and dynamic market systems. Using cross-country secondary quantitative panel data (2013, 2015, 2017 and 2019) from 39 countries, owned by the Organisation for Economic Co-operation and Development (OECD), the research examines through hierarchical regression how market dynamics and collaboration networks interacts to impact radical innovation. Findings demonstrate that the elements, which influence radical innovation the most are technological turbulence and cooperation activities with clients. Additionally, they assert that market dynamics and collaboration networks are complementary and need to be analysed together when firms desire to implement radical innovation. This results offer theoretical contributions by i) integrating these two perspectives, i.e. Evolutionary Theory of Innovation and Market-Shaping perspectives and empirically demonstrating their combined effect on radical innovation; ii) providing evidences of the interaction between two different levels of the market. Additionally, managerial implications highlight the need for firms to view competition and technological turbulence as catalysts rather than threats, while strategically managing collaboration networks to enhance innovation outcomes. By bridging theoretical and practical domains, this study provides actionable insights into how firms can navigate and influence complex market environments to foster radical innovation.

Keywords: Market dynamics, Collaboration networks, Radical innovation, Strategic marketing, Secondary data.

FIGURES SUMMARY

TABLE SUMMARY

SUMMARY

1 INTRODUCTION

Innovation has long been a cornerstone of competitive advantage, driving the transformative potential of organizations and industries alike. Among the diverse forms of innovation, radical innovation stands out for its ability to redefine markets, disrupt industries, and propel economies forward (Flaig, Kindström, & Ottosson, 2021b; OECD & Eurostat, 2005; Schumpeter, 1997). In this realm, radical innovation is understood as a new product or process, result of environmental turbulence, institutional pressures, organizational culture and processes, inter-organizational interaction and/or resource allocation, which is available for use and/or consumption (Garcia & Calantone, 2002; Harmancioglu, Droge, & Calantone, 2009; OECD & Eurostat, 2018; Ojha, Struckell, Acharya, & Patel, 2020). However, the realization of such breakthroughs often transcends the boundaries of individual firms, necessitating interaction between external market dynamics (Randhawa, Wilden, & Gudergan, 2021; Tang, Zhang, & Peng, 2021; Turulja & Bajgoric, 2019) and collaboration networks (Baker & Nenonen, 2020; Möller, Nenonen, & Storbacka, 2020). This thesis explores the interaction of these two forces – market dynamics and collaboration networks – to foster radical innovation, a critical yet underexplored frontier in strategic marketing and innovation studies.

In this sense, markets are considered a set of interconnected systems formed by coevolving actors and pressures influencing the way firms develop abilities to sense the market and seize opportunities (Shaw, 2020; Zhang & Watson IV, 2020). These systems are complex, multi-layered, nested and transitional (Möller et al., 2020; Schumpeter, 1997), that is, formed by interrelated business systems organized in different levels and continuously changing. In this regard, market dynamics, composed by competitive intensity and technological turbulence, pertains to layers more distant to the firms and collaboration networks, comprising cooperation activities with clients, suppliers and high education and government institutions, are proximate, with a higher power of firm's intervention.

Market dynamics, characterized by competitive intensity and technological turbulence, create both opportunities and pressures for organizations (OECD & Eurostat, 2018; Tang et al., 2021; Yu, Hao, Ahlstrom, Si, & Liang, 2014). These forces can catalyse innovation by stimulating firms to differentiate themselves and adapt swiftly to changing environments (Kohli & Jaworski, 2023; Nenonen & Storbacka, 2018; R. Varadarajan, 2020a). Simultaneously, collaboration networks, encompassing cooperation activities with suppliers, clients, higher education and government institutions, provide the resources, knowledge, and synergies needed to navigate complex innovation landscapes (Antràs, 2020; Efrat, Gilboa, &

Yonatany, 2017; Genc, Dayan, & Genc, 2019; D. Kafetzopoulos & Skalkos, 2019; Mira-Solves, Estrada-Cruz, & Gómez-Gras, 2021; Munksgaard & Medlin, 2014; Roper & Turner, 2020; Walter, Auer, & Ritter, 2006; Yu et al., 2014). Together, market dynamics and collaboration networks form a dual complementary engine, wherein market dynamics set the stage, and collaboration networks provide the tools for innovation to thrive.

Building upon the Evolutionary Theory of Innovation and Market-Shaping perspectives, this research positions firms as pertaining to multi-layered, complex and evolutionary system, where they are active participants in shaping their environments (Nelson & Winter, 1977; Nenonen & Storbacka, 2018). These perspectives have differences in scope, but they share assumptions and provide a unique prism to investigate radical innovation phenomenon. By leveraging collaboration networks strategically, firms not only adapt to but also influence market dynamics (Baker & Nenonen, 2020; Möller et al., 2020). This reciprocal relationship suggests a complementarity between market dynamics and collaboration networks, which, when aligned, amplifies the potential for radical innovation.

This study contributes to the literature by examining this complementarity between different layers that compose the environment to favour innovation, i.e. market dynamics and collaboration networks. Therefore, it approximates theoretical frameworks to reality and advance literature to better comprehend complex interaction between market layers, beyond the idea of firm adaptation to the environment changes. Through an empirical analysis with cross-country secondary quantitative panel data from the Organisation for Economic Co-operation and Development (OECD), it offers insights into firms sensing the environment (Kleinaltenkamp, Karpen, & Kleinaltenkamp, 2022), e.g. through the complementarity of different market layers, i.e. market dynamics and collaboration networks, to achieve innovation-driven success. It underscores the importance of viewing innovation not merely as a reactive process but as a proactive endeavour shaped by the interplay of external forces and strategic collaborations (Filippetti, Gkotsis, Vezzani, & Zinilli, 2020; Kohli & Jaworski, 2023; Schulze, Townsend, & Talay, 2022).

By bridging the theoretical and practical domains, this thesis aims to provide both academic and managerial implications, guiding firms on harnessing the synergy of market dynamics and collaboration networks to navigate the complexities of radical innovation.

Next, the research problem is deployed.

1.1 RESEARCH PROBLEM

Radical innovation, recognized for its disruptive potential and ability to redefine markets (Flaig et al., 2021b), is a key driver for competitive advantage (Azeem, Ahmed, Haider, & Sajjad, 2021; Naidoo, 2010) and economic growth (Di. Kafetzopoulos, Gotzamani, & Vouzas, 2021; OECD & Eurostat, 2018). However, its deployment remains a complex endeavour influenced by both external environmental conditions (Filippetti et al., 2020; Ojha et al., 2020) and internal strategic decisions (Azeem et al., 2021; Costa & Didonet, 2020; D'souza, Nanere, Marimuthu, Arwani, & Nguyen, 2021; Hussain, Mujtaba, Shaheen, Akram, & Arshad, 2022; Martínez-Román & Romero, 2017; Naidoo, 2010; Nieves & Diaz-Meneses, 2016; Parida, Pesämaa, Wincent, & Westerberg, 2017; Schulze et al., 2022). Balancing these two settings is a concern present in marketing domain and a prominent research opportunity (Baker & Nenonen, 2020; Layton, 2015; Möller et al., 2020; Nenonen, Storbacka, & Windahl, 2019; Shaw, 2020; R. Varadarajan, 2020a).

In this sense, market dynamics, e.g. competitive intensity and technological turbulence, are positioned as catalyst for innovation, pressuring firms to differentiate and adapt (Tang et al., 2021; Yu et al., 2014). Meanwhile, collaboration networks, including cooperation activities with suppliers, clients, high education and government institutions, provide firms with critical resources, knowledge, and capabilities to overcome innovation barriers (Di. Kafetzopoulos et al., 2021; OECD & Eurostat, 2018; Zacca, Dayan, & Ahrens, 2015).

Despite extensive research exploring market dynamics, collaboration networks and innovation, significant gaps persist underdeveloped to understand the interplay between market dynamics and collaboration networks in fostering radical innovation. Existing studies often examine the effects of these elements isolated (Ardito, Messeni Petruzzelli, & Albino, 2015; Azeem et al., 2021; Costa & Didonet, 2020; D'souza et al., 2021; Filippetti et al., 2020; Martínez-Román & Romero, 2017; Nakata & Hwang, 2020; Nieves & Diaz-Meneses, 2016; Parida et al., 2017; Rammal et al., 2022; Schulze et al., 2022). In these sense market dynamics are treated as external antecedents or moderators of innovation, and organizations have little to no power to modify it (Chandy & Tellis, 1998; Rousseau, Mathias, Madden, & Crook, 2016; Tang et al., 2021; Yu et al., 2014). By its turn, collaboration networks are seen as resource-oriented mechanism to enhance performance (Genc et al., 2019; Di. Kafetzopoulos et al., 2021; Mira-Solves et al., 2021; Parida et al., 2017; Walter et al., 2006). While these perspectives mentioned before offer valuable insights, they fail to capture the synergistic relationship between different levels of the firm's environment (Baker & Nenonen, 2020; Möller et al.,

2020), i.e. market dynamics and collaboration networks particularly how their complementarity can amplify the likelihood of radical innovation.

Therefore, the first gap this research seeks to address is that studies so far have explored competitive intensity and technological turbulence as innovation drivers, predominantly as external forces and hazards (Hughes & Chandy, 2021; Ojha et al., 2020; Rousseau et al., 2016; Tang et al., 2021; Yu et al., 2014), rather than integrated elements interacting with firms' strategic efforts, such as collaboration networks.

The second gap refers to the lack of literature exploring collaboration networks under the motivation of resources access (Costa & Didonet, 2020; Farida & Nuryakin, 2021; Genc et al., 2019; Parida et al., 2017; Walter et al., 2006; Yu et al., 2014). This view associates collaboration networks to a static view of conduits for resource exchange, overlooking their dynamic role in shaping markets environments (Flaig et al., 2021b; Flaig, Kindström, & Ottosson, 2021a) and enabling firms to act proactively to market changes (Kohli & Jaworski, 2023).

Third, there is a literature gap regarding empirical evidences on the combined effect of different levels that compose markets (El-Ansary, Shaw, & Lazer, 2018; Kohli & Jaworski, 2023; Layton, 2015; Shaw, 2020). Specifically, this research explores the complementarity between market dynamics and collaboration networks, that is, how their alignment can facilitate radical innovation. This relationship is underexplored, but proposed due to the nested and multi-layered nature of market systems, as suggested by the evolutionary theory of innovation (Dosi, 1982; Nelson & Winter, 1977) and the market-shaping theoretical approach (Flaig et al., 2021a, 2021b; Jaworski, Kohli, & Sarin, 2020; Möller et al., 2020; Nenonen & Storbacka, 2018).

These gaps raise the following research question: **How market dynamics and collaboration networks interacts to impact radical innovation?**

The next section declares the research objectives.

1.2 RESEARCH OBJECTIVES

Based on the research question, the following research objectives were established to guide this study.

1.2.1 General objective

The general objective of this is research is to explore the complementarity of market dynamics and collaboration networks to favour radical innovation.

1.2.2 Specific objectives

To accomplish the general objective, it was necessary to depict it into more specific and narrow objectives as it follows:

- Verify the influence of market dynamics on radical innovation
- Verify the influence of collaboration networks on radical innovation
- Assess the market dynamics and collaboration networks complementarity to favour innovation

1.3 RESEARCH JUSTIFICATION

The research justifications to achieve the above mentioned objectives were split into theoretical and empirical justification.

1.3.1 Theoretical justification

Radical innovation is a transformative phenomenon with profound implications for markets and economies (Filippetti et al., 2020; OECD & Eurostat, 2018). Despite its significance, existing research often treats enabling factors, e.g. market dynamics and collaboration networks, in silos (Ardito et al., 2015; Azeem et al., 2021; Costa & Didonet, 2020; D'souza et al., 2021; Filippetti et al., 2020; Martínez-Román & Romero, 2017; Nakata & Hwang, 2020; Nieves & Diaz-Meneses, 2016; Parida et al., 2017; Rammal et al., 2022; Schulze et al., 2022), neglecting their potential complementarity. This is linked to the theoretical approaches such as organizational culture, dynamics capabilities and resources based view, which focus on firms mind-set, resources and capabilities (e.g., Azeem et al., 2021; D'souza et al., 2021; Parida et al., 2017). While the evolutionary theory of innovation highlights the iterative interaction between firms and market environments (Nelson & Winter, 1977), and market shaping perspective emphasize proactive strategies for reshaping markets (Nenonen & Storbacka, 2018), there is limited understanding about these two approaches convergence to explain radical innovation.

Therefore, the first theoretical justification is integrating market dynamics and collaboration networks in the same study as innovation antecedents. Deriving from the combination of the two theoretical perspectives said before, to posit market dynamic and collaboration networks together as antecedents, otherwise, while one would act as an antecedent the other would be treat a moderator or a control variable. For example, when the focus is on

verifying the network aspects, market dynamics elements frequently comes as control variable (e.g. Torkkeli, Kuivalainen, Saarenketo, & Puumalainen, 2016; Walter et al., 2006). When treated as moderator or control variable, literature admits both have influence on innovation; however, they do not play a triggering role simultaneously. More than that, this research bridges these domains by examining their combined influence on radical innovation.

The second theoretical justification is deepening the understanding of the nested and multi-layered nature of markets (Layton, 2015; Möller et al., 2020; Shaw, 2020), providing evidences of two different market levels interaction. This was possible by the evolutionary theory of innovation and market shaping approach assumptions rooted on systems theory (Giesler & Fischer, 2017). That is, combining these two theories, which have focus on different levels of these complex systems that are markets.

The third theoretical justification is understanding collaboration network beyond the static path to access resources firms do not possess (Costa & Didonet, 2020; Farida & Nuryakin, 2021; Parida et al., 2017; Walter et al., 2006). Combining it with market dynamics and verifying its complementarity, it shed light to a more strategic role of networks, acting as a prolific strategy to change markets.

Summarizing, this thesis is justified by the proposal of a holistic framework for understanding how firms navigate and influence complex market environments to foster radical innovation that are capable to transform the environment.

1.3.2 Managerial justification

Rapidly evolving business landscapes are a reality to most organizations, where firms face mounting pressures from dynamic markets and technological disruptions (Keskin et al., 2021; R. Varadarajan, 2020a). Managers are tasked with balancing reactive strategies to adapt market changes with proactive approaches to shape markets into its own benefit (Jaworski et al., 2020; Kohli & Jaworski, 2023; Nenonen & Storbacka, 2018). Therefore, this research offers some actionable insights for managers aiming to achieve radical innovation.

The first insight is due to market dynamics. Usually marketers see competition intensity and technological turbulence as threats and a challenge (Chandy & Tellis, 1998; Hughes & Chandy, 2021; Rousseau et al., 2016; Tang et al., 2021; Yu et al., 2014), rather than opportunities. This research calls practitioners to a different state of mind where competitive intensity and technological turbulence can serve as innovation catalysts, helping firms to differentiate themselves and seize market opportunities.

The second justification to managers is about collaboration networks collaborating to radical innovation increase. In this sense, it is proposed for firms to look into each type of linkages, e.g. cooperation with clients, suppliers, high education and government institutions, to strategically design and manage networks (A. F. Maciel & Fischer, 2020; Möller et al., 2020). Dealing with networks is intrinsic to firm's routine. Previous research already explored the abilities managers must develop to create and manage their relationships in order to access new resources and capabilities (Costa & Didonet, 2020; Farida & Nuryakin, 2021; Parida et al., 2017). This thesis focus on the network players, within which the firm establishes linkages, understanding that managers strategically choose stakeholders to relate with in order to achieve firm's specific goals (Gulati, 1998; Gulati, Nohria, & Zaheer, 2000). Consequently, it is argued that firms might enhance radical innovation depending on to whom they relate with.

Third, managers can benefit from a deeper understanding about how market dynamics and collaboration networks work in tandem (Möller et al., 2020). This alignment allows firms to respond to and anticipate environmental changes more effectively, improving innovation outcomes and fostering long-term competitiveness.

Summarizing, this research provides insights for firms to develop innovation considering simultaneously its market dynamics and collaboration networks.

2 LITERATURE REVIEW

2.1 MARKET DYNAMICS AND MARKETING

Since the ‘50s, environmental factors have been an interest of marketing literature due to the focus shift from production to the necessity of managing mass markets (El-Ansary et al., 2018; R. Varadarajan, 2020a; Wilkie & Moore, 2003). When competition raised, strategic marketing scholars direct efforts on studying the competitive landscape (Jayachandran, Gimeno, & Varadarajan, 1999). Understanding markets by competitors’ forces was essential to gain and maintain competitive advantage, which was posited as the firm differentiation in face of its competitors and synonym of success (Porter, 1991). When strategic marketing literature incorporate the concept of market orientation, costumers were another aspect of market dynamics considered to have impact on the organization (Narver & Slater, 1990).

Due to the high influence of economics in strategic marketing literature, turbulence have become another concept of matter of this field when studying the environment (Challagalla, Murtha, & Jaworski, 2014; R. Varadarajan, 2015). In this sense, studies had explored market turbulence linked to the idea of substantive changes, the opposite of stability, and it is composed by three different aspects (Challagalla et al., 2014; Jayachandran et al., 1999; Keskin et al., 2021; Martin & Javalgi, 2016; Ojha et al., 2020; Sood & Tellis, 2005). The first is customer turbulence, which is the change in customer needs and desires (Ojha et al., 2020). The second aspect, is competitive turbulence, which is known as: i) the volume of players in the market, uncertainty of competitors strategy (Challagalla et al., 2014), ii) how offensive competition is perceived (competitors aggressiveness) (Jayachandran et al., 1999; Martin & Javalgi, 2016), iii) how fast is competitors response to organization’s actions (Keskin et al., 2021) or iv) how difficult is for new players to get into the market. The third aspect is, technological turbulence, which comprises the velocity of new technology release or how fast a technology becomes obsolete (Sood & Tellis, 2005; Yu et al., 2014).

Within the maturity of marketing domain, the environment and its dynamics is given as crucial to marketing strategy (R. Varadarajan, 2015). The market dynamics relevance is due to its influence on marketing decisions and their performance (Layton, 2015; Shaw, 2020). However, more than being responsive to market dynamics, strategic marketing research also identified the proactive behaviour of firms to interact (Barrales-Molina, Martínez-López, & Gázquez-Abad, 2013; Kachouie, Mavondo, & Sands, 2018; Narver, Slater, & MacLachlan, 2004) and shape the market (Flaig et al., 2021b, 2021a; Jaworski et al., 2020). Then, marketing

function plays the hole of boundary-spanning the organization (Hult, 2011), thinking and executing the marketing strategy (R. Varadarajan, 2010) and creating an organizational culture of being aware about the environment (Narver & Slater, 1990).

This research focuses on the environment conception of an ecosystem of actors and pressures in constant interaction to coevolution. In this sense, marketing decisions and actions are influenced by and influence the environment through its outcomes in an evolutionary manner (Baker & Nenonen, 2020; Layton, 2015; Shaw, 2020). Ecosystems are complex contexts consisting in nested systems composed by diverse interacting elements, which interactions are nonlinear (Layton, 2015; Möller et al., 2020). Moreover, it investigates market dynamics with a focus on environmental changes. Literature in other fields had investigated environment dynamics as turbulence in diverse aspects of the environment, such as quick changes in consumers' needs and preferences (Turulja & Bajgoric, 2019), competitive intensity (Calantone, Harmancioglu, & Droge, 2010), speed and frequency of new technology release (Candi, Van Den Ende, & Gemser, 2013; Efrat et al., 2017), and economic and political volatility. However, turbulence concept is usually associated with the idea of hazards and threads, in which the organization has little power to change (Calantone et al., 2010; Candi et al., 2013; Efrat et al., 2017; Turulja & Bajgoric, 2019).

Regarding theoretical perspectives, some studies explored a view of the environment through the lens of contingency theory (Chandler, 1962) providing structure adaptation arguments to match the environment, originating concepts of flexibility (Fredericks, 2005), environmental awareness, adaptability and environment-strategy fit (Li, Gordon, & Netzer, 2018). In this sense, marketing could benefit the organization as a function to sense environment and turn market information into strategic insights to match firm structures to the environment (Fredericks, 2005; Li et al., 2018). Other studies, inspired by the resource-based view (RBV) (Barney, 1991), grounded on resource dependence theory (Aldrich & Pfeffer, 1976), assigned questions such as to which relevant marketing resources to dedicate efforts, how can managers combine marketing resources to provide favourable outcomes (O'Toole & McGrath, 2018; R. Varadarajan, 2020b), what alliances should the firm invest on to access crucial resources, and how they should be managed to provide resources in a favourable manner (O'Toole & McGrath, 2018; Parida et al., 2017; Veiga & Franco, 2015). In this case, the arguments focus on internal factors with environmental factors playing a static secondary role.

Nonetheless, more recent theoretical streams suggest firms are capable of influencing the environment by introducing new products and technologies to the market (Thoumrungroje & Racela, 2021), influencing customer behaviour and expectation (Kindström, Ottosson, &

Carlborg, 2018) and even changing public policies (Kjellberg, Azimont, & Reid, 2015). Therefore, literature assumes organizations are driven by the market and they also can drive market changes (Randhawa et al., 2021; Tang et al., 2021). This assumption raises the necessity of marketing researchers to explore the influence of the environment in marketing decisions as well as the other way around.

In this realm, literature conceive innovation as a manner of firms to promote market changes (Flaig et al., 2021b; Stathakopoulos, Kottikas, Painesis, Theodorakis, & Kottika, 2022), because innovations require organization efforts to change market dynamics to have success in the market (Peters, Nenonen, Polese, Frow, & Payne, 2020). The innovation success is considered when the new or improved products and business process are available and used buy customers and/or the organization (OECD & Eurostat, 2018).

In an attempt to further understand the relationship between market dynamics, marketing strategy and innovation themes, this study rely on two theoretical perspectives, which are the evolutionary theory of the firm (Nelson & Winter, 1977) and market shaping approach (Nenonen & Storbacka, 2018).

2.2 EVOLUTIONARY THEORY OF INNOVATION

Also called as neo-Schumpeterian theory, the evolutionary theory of innovation (ETI) opposes the linear vision of innovation advocated by the époque mainstream economics mind-set, where innovation outcomes were directly related to financial support. Based on Schumpeterian economic cycles, ETI's authors argue that innovation resemble a cumulative, rigorous and consistent research path (Meirelles, 2009; Rosenberg, 1969). They defend that trivial changes in processes and products should not be considered innovations and that modifications and improvements need to be significant such as new features, gains of efficiency and efficacy, and so on (Nelson & Winter, 1977).

Regarding path-dependence (Nelson & Winter, 1977; Tigre, 2009), ETI affirms that innovation is conditioned to previous technologies and context. The context in this theory is considered as market structures, i.e., how sectors are organized, and the institutions, i.e., the complex net of agents and beliefs (Meirelles, 2009; Nelson & Winter, 1977). This historical-context relation supports the argument of innovation being a cumulative, learning-based result (McKelvey & Saemundsson, 2018). Further, this path dependency also bases the argument to establish the concept of economic cycles (Filippetti et al., 2020; Vlados, Koronis, & Chatzinikolaou, 2021), where economic scenarios depend on the previous one.

Literature also presents the notion of contextual trajectory, which is similar to the path-dependence concept. In this sense, contextual trajectories are defined as patterns related to the market phenomena. These patterns involve technology trends, demographic scenario, regulatory issues or general environmental factors (Hughes & Chandy, 2021).

Although ETI considers that innovation takes place within the organization and that decision-makers are part of the randomness of the innovation results, its roots in economics focus the researchers discussion on markets, which are constituted by economic, political, social and competitive systems (Schumpeter, 1997). Therefore, markets are formed by economic fluctuations, which originate in streams of objective causality (Nelson & Winter, 1977). That is, markets are organized and interact continuously in periods of expansion – characterized by growth in gross domestic product, inflation and unemployment at low levels and exchange rate stability, and recession – identified by falling current gross domestic product, rising inflation and unemployment levels, and exchange rate instability (Grewal & Tansuhaj, 2001; Mankiw, 2014). Nevertheless, innovation is a cornerstone on understanding these fluctuations, what is discussed next.

2.2.1 Innovation role in ETI

Even though ETI is a theory to explain economics dynamics, innovation is central to ETI's discussion, because innovation is considered as the motor of expansion periods, triggering investments, fomenting prosperity and raising employment levels (Schumpeter, 1997). Moreover, innovation comes from a process, which is stochastic (Meirelles, 2009; Possas, 2008), meaning that a random behaviour is expected in innovation outcomes. This unpredictability is related to the idiosyncrasy of agents involved in the process of innovation, who make decisions under uncertainty (Meirelles, 2009). Uncertainty occurs by aggregating turbulence in economic and political scenarios, technologies to be released, market demand and competitive landscape (Camisón & Villar-López, 2014; Ojha et al., 2020).

In addition to the random aspect of innovation, and incorporating environment changes as an innovation trigger, ETI also has a relevant assumption of innovation being path-dependent (Tigre, 2009). It means that innovation is conditioned on how choices about resources and capabilities are made, which are guided by managers' and decision-makers' economic interests (Perez, 2010). In this sense, decision-making literature argues that managers shape their decisions in risk perception, how they perceive the turbulence as a threat or as an opportunity (Gagliardi & Iammarino, 2018; Sjöberg, 2000). Therefore, a component of perception is how

the turbulence will be presented to the decision-maker, i.e., as an arrangement of diverse systems turbulence (Shaw, 2020; Zhang & Watson IV, 2020).

Technologies also follow a trajectory, which is shaped by the economic interests of decision-makers and the interaction between the organization and activity sector (Dosi, 1982; Perez, 2010). Trajectory is also a dynamic market attribute, that can be contextual – derived from customers, competitors and macro-environment patterns, and strategic – firm-specific patterns (Hughes & Chandy, 2021). Result of this innovation-market interaction, innovations are selected by the market (OECD & Eurostat, 2005, 2018; Vlados et al., 2021). The selection occurs under the logic of using, buying or applying the new or improved product or business process by the market players (OECD & Eurostat, 2018). Subsequently the market selection, the accepted innovations are continued or modified and the ones that are not accepted are then discontinued (Meirelles, 2009; Perez, 2010). In this case, the first innovations with a major degree of novelty are called radical ones, and the latest improvements and modifications are considered incremental innovations (McKelvey & Saemundsson, 2018; Perez, 2010).

This feedback process of selection of market acceptance and adaptation infers a learning characteristic. It is through learning that firms analyse market responses to innovations and direct their efforts to acquire and develop new resources and capabilities (Sok, O'Cass, & Sok, 2013). That means that, if innovation is accepted by the market, managers tend to acquire resources and develop capabilities for having success continually. In this realm, literature explores and provide evidences of knowledge and learning capabilities favouring innovation outcomes (Hurley & Hult, 1998; Hussain et al., 2022; Nieves & Diaz-Meneses, 2016).

Nonetheless, when ETI's studies mention innovation, they concentrate to conceptualize it by a technological point of view (Hughes & Chandy, 2021; McKelvey & Saemundsson, 2018; Vlados et al., 2021). However, broad innovation literature has different conceptions about innovation nature and consider an extended range of innovation classification (Garcia & Calantone, 2002; Kahn, 2018; OECD & Eurostat, 2005, 2018), which can enrich ETI's developments, what is discussed in the following section.

2.2.2 Innovation concept

Innovation is a multidimensional concept and can be comprehended from three different perspectives: as a mind-set, as a process or as an outcome (Kahn, 2018). As a mind-set, innovation is responsible for culturally internalizing through the whole organization a state of mind to develop innovative initiatives (Hurley, Hult, & Knight, 2005; Martínez-Román &

Romero, 2017; Quandt, Bezerra, & Ferraresi, 2015). As a process, innovation can be understood as a sequence of steps, phases or activities in which innovation should be organized to provide desired outcomes (Brown, 2017). As an outcome, innovation is considered a result of environmental turbulence, institutional pressures, organizational culture and processes, inter-organizational interaction and/or resource allocation (Garcia & Calantone, 2002; Harmancioglu et al., 2009; Ojha et al., 2020). Despite different forms to approach innovation, novelty and newness frame is always associated with all of them (Baregheh, Rowley, & Sambrook, 2009).

The perspectives before-mentioned are not mutually exclusive; innovation literature frequently combines manners of understanding the concept to uncover its nuances (Magistretti, Ardito, & Petruzzelli, 2021; Martínez-Román & Romero, 2017; Nakata & Hwang, 2020). For example, Martínez-Román and Romero (2017) focused their investigation on innovativeness, which is defined as the level of innovation integrated within the organization and its ability to bring radical innovations to the market. However, they also considered innovation as a result of innovativeness, being radical innovation the disruptive knowledge (Martínez-Román & Romero, 2017). Nakata and Hwang (2020) investigated a process perspective of innovation suggesting dynamics for design thinking, which is a practice-led concept in the innovation literature. They also measured its impact on innovation success, which is defined as new products and services performance, an outcome perspective of innovation (Nakata & Hwang, 2020). Another example is the research of Magistretti, Ardito and Petruxxelli (2021) who explored the process of design thinking. However, they addressed design thinking as a dynamic capability of firms that foster innovation (Magistretti et al., 2021).

In this research, innovation is studied as an outcome, meaning that it is a result derived from internal and external antecedents. In this case, the taxonomy of innovation is a subject of matter and literature provides three main categories (OECD & Eurostat, 2005). The first is classifying innovation according to its degree of novelty, that is, if the outcome is something really new or an incremental improvement (Garcia & Calantone, 2002). The second pertains to the realm of the level at which the improvement is perceived as new. In this case, if the improvement is new to the organization it is considered an innovation at the micro level, and if the improvement is new to the market is an innovation at the macro level (Garcia & Calantone, 2002; Martínez-Román & Romero, 2017). The last category classifies innovation through the nature or subject of the improvement. Hence, if the improvement is a new product feature it is considered a product innovation; if it occurs in how this is done it is considered a process innovation; if it is the implementation of new or improved marketing methods it is a marketing innovation; and if the changes are directed to organizational structures they are organizational

innovations (OECD & Eurostat, 2005, 2018). When understanding innovation as a result, the literature investigates different antecedents and outcomes innovation might interact with and this diversity reflects the variety of theoretical lenses and domains that support the body of research on such a complex construct (Harmancioglu et al., 2009).

Regarding the antecedents of innovation, researchers explored and evidenced them at different levels. Some inside-organization triggers, also called micro-level ones, are such as knowledge, innovation, learning and network capabilities (Costa & Didonet, 2020; Hussain et al., 2022; Nieves & Diaz-Meneses, 2016; Parida et al., 2017), innovativeness and market orientation (Azeem et al., 2021; D'souza et al., 2021; Martínez-Román & Romero, 2017; Naidoo, 2010; Schulze et al., 2022). Size and time of operation are also considered innovation antecedents, perceived as meso-level triggers, on the level of groups of organizations, and have been studied as both innovation antecedents or control variables (Camisón & Villar-López, 2014; Mothe & Nguyen, 2010; Nakata & Hwang, 2020; Rousseau et al., 2016; Schulze et al., 2022). Macroeconomic elements are considered innovation triggers as well. At such level, evidence were found about sector characteristics (Mothe & Nguyen, 2010; Rousseau et al., 2016), competition dynamics, clusters and economic and political environment (Ardito et al., 2015; Camisón & Villar-López, 2014; Filippetti et al., 2020).

Literature provides plenty of evidence about micro and meso-level innovation antecedents, as mentioned before. However, macro-level antecedents are explored as hazards or control variables, being a research opportunity for the inquiry about those innovation trigging elements. This concentration of studies may be due to the prevalence of some theoretical lenses such as contingency theory and resource-based view (Harmancioglu et al., 2009), the first one considers external pressures as hazards and organizations' actions and decisions are made to respond and react to them (Chandler, 1962), and the second one focus on internal aspects such as resources arrangement and capabilities development to achieve competitive advantages (Barney, 1990).

The outcomes of innovation has been studied in several manners such as the increase in competitive advantage (Azeem et al., 2021; Naidoo, 2010); operational flexibility (Ojha et al., 2020); financial, production and market performance (D'souza et al., 2021; Gunday, Ulusoy, Kilic, & Alpkan, 2011; Naidoo, 2010). In these cases, the theoretical background to support the innovation outcomes are the same approaches as the ones used to suggest innovation antecedents. Consequently, the relation between innovation and its outcomes is linear (Azeem et al., 2021; D'souza et al., 2021; Gunday et al., 2011; Naidoo, 2010; Ojha et al., 2020), i.e., the better the firm is aware of its environment and is prompt to respond to pressures and the better

it develops valuable capabilities, the better it will be the innovation outcomes. However, there is a body of literature reinforcing the longitudinal characteristic of innovation, suggesting that there is an iterative relation between innovation and internal and external elements of the firm, the then-called antecedents and consequents of innovation (Filippetti et al., 2020; Maravelakis, Bilalis, Antoniadis, Jones, & Moustakis, 2006; Perez, 2010; Schulze et al., 2022; Teece, Peteraf, & Leih, 2016). In other words, the environment dynamics influence innovation and it can change them subsequently.

Additionally, innovation is frequently associated with its environment, that is, market, public policies, technological ambience and competitive setting (Camisón & Villar-López, 2014; Filippetti et al., 2020; Ojha et al., 2020; Paiva, Cunha, Souza Junior, & Constantino, 2018). This is due to the core aspects of innovation definition, i.e., the new products and business processes or their improvements must be available to the users (OECD & Eurostat, 2018), and to the economic roots that associated innovation with economic growth (Schumpeter, 1997). Thence, it has been argued for a long time that innovation and the economy of countries are intrinsically linked and change in the long term (Nelson & Winter, 1977; Schumpeter, 1997). For this reason, innovation and its relation with environmental dynamics are a recent concern in marketing research (Hughes & Chandy, 2021; Kachouie et al., 2018; Schulze et al., 2022; Zhou, Mavondo, & Saunders, 2019).

In this research, ETI bases the comprehension about the relationship between market dynamics and innovation. As described in the sections before, innovation has a trajectory, and diverse aspects act to favour its emergence (Gelper, Peres, & Eliashberg, 2018; McKelvey & Saemundsson, 2018). However, there is also a random effect, which has many sources, including organizations idiosyncrasies, e.g. an agent component of attitude, and are not the focus of ETI (Nelson & Winter, 1977; Schumpeter, 1997). “Agent” here is not associated with the Agency Theory, but the proactive organizations’ actions towards the market dynamics. Therefore, it is called market shaping theoretical approach, due to the literature compilation and advances regarding organizations proactive actions to shape markets.

2.3 MARKET SHAPING APPROACH

Market-shaping research has gained attention of strategic marketing literature due their focus on understanding firms role in changing market dynamics (Jaworski et al., 2020; Stathakopoulos et al., 2022). Market-shaping approach *corpus* understands markets as complex sets of value creating systems where institutional arrangements are responsible to manage

stakeholders' roles and behaviours (Nenonen et al., 2019). Markets are also formed by different levels, named market trends and industry forces (Jaworski et al., 2020). Market trends are more "exogenous" forces and difficult to be influenced by a single firm effort, for example, economic setting or political landscape (Jaworski et al., 2020). Industry forces, by its turn, are more willing to be changed by organization endeavour, for example, value networks, buyer power or substitute technologies (Jaworski et al., 2020). Additionally, markets are continuously shaped by a set of shaping strategies and activities performed by these stakeholders (Flaig et al., 2021b). Therefore, market shaping firms are the ones that actively develop and exploit their business model and marketing mix to modify how resources are changed (Nenonen et al., 2019) in order to incite value gains from greater market size, efficiency, and profitability (Nenonen & Storbacka, 2018).

In this sense, changes that are consequence of competition processes, i.e. response to competitors' movements that are intrinsic to today's economic activities, are not considered market-shaping results (Nenonen & Storbacka, 2018). It implies that a decision and/or an action will be considered pertaining to the market shaping scope when a focal firm purposively acts to change market characteristics (Nenonen et al., 2019). These actions are manifested by, for example, re-designing the exchange content, reconfiguring stakeholders' network, reforming institutions (Nenonen et al., 2019) or through origination and propagation of valuable new resource linkages (Kleinaltenkamp et al., 2022).

Nonetheless, market shaping efforts rarely occur in isolation (Flaig et al., 2021b) or have a simple and perfect impact on market level characteristics (Nenonen et al., 2019). At the same time a firm acts to change market characteristics in a sense to improve its own value, other players want to maintain their advantage and develop market shaping strategies to stanch any threat to hinder their value (Flaig et al., 2021b). Hence, markets are filled with different market shaping strategies that act as forces from different players, which together dictates environment dynamics.

To explore these forces, there are some study streams, which can be focused on agents' intentionality, markets enactment and constructivist aspects, to comprehend the proactive aspects of market shaping (Flaig et al., 2021b; Kjellberg et al., 2015; Kleinaltenkamp et al., 2022; Nøjgaard & Bajde, 2021). For example, when highlighting agents' intentionality, Flaig et al. (2021b) combined market shapers perception of market dynamics and their intention when analysing market-shaping strategies. This combination results in four different market shaping strategies – which are market reduction, market maintenance, market widening and market

disruption –, and the results the strategies might lead – monopolization, market resilience, market growth and new market, detailed in item 2.3.1 (Flaig et al., 2021b).

Another example is the concept of enactment when studding market shaping through the lens of institutional theory. In this view, the market dynamics will only be considered dynamic when market shapers attribute meanings, make sense and propagate it to refine the meanings. That is, any environmental stimulus would be relevant if the participants consider it as relevant. Otherwise, it will not culminate in actions, i.e. market shaping strategies (Kleinaltenkamp et al., 2022).

From a perspective of market construction, constructivist market studies contribute to market shaping strategies deepening the knowledge about dynamics to construct markets (Giovanni & Vieira, 2023; Kjellberg et al., 2015). In this stream, literature reinforces the conception that markets are seen as a phenomena of constant changes, instead of static structures, and are formed by different agents (Kjellberg et al., 2015). Therefore, markets are continuously constructed by market practices of several players, including buyers, sellers, regulators, intermediaries and non-government organizations (Kjellberg et al., 2015; Nøjgaard & Bajde, 2021). Hence, this stream of research focuses on to study how markets are formed (Nøjgaard & Bajde, 2021). In this context, innovations are market arrangements, which alters social and economic orders (G. N. Maciel & Leme, 2023).

Altogether, these perspectives are relevant to the development of concepts and categories of market-shaping literature. This research directs to understand market-shaping focusing on the agent's intentionality, specifically strategies taken proactively to shape market dynamics.

TABLE 1 summarizes the assumptions of both theoretical approaches combined in this research

TABLE 1 – THEORETICAL APPROACHES SUMMARY

Evolutionary theory of innovation (Meirelles, 2009; Nelson & Winter, 1977)	Market-shaping approach (Flaig et al., 2021a; Nenonen & Storbacka, 2018)
• Emphasises institutional evolution t favour innovation • Rooted on economic systems theories	• Highlights the organizational purposive actions to change market characteristics
Shared assumptions	
• Systems iteration, that is, systems are multi-layered, nested and transitional. • Comprehension that innovation and knowledge are cumulative. • Decisions are path dependent, i.e. decisions taken today are conditioned to the previous one.	

2.3.1 Market-shaping strategies

A central aspect about market-shaping studies are the firm practices to shape the market, that is, firm's strategies (Nenonen & Storbacka, 2018). Strategic marketing literature already signal interest in these actions, when it considered firms hole in driving markets (Jaworski et al., 2020; J. N. Sheth & Parvatiyar, 2021). Therefore, market-shaping strategies are valuable to marketing scholars also because they enable firms to enhance their competitiveness and performance (Flaig et al., 2021b; Stathakopoulos et al., 2022). Literature defines market-shaping strategies as "the set of purposeful activities a firm employs to shape a market in order to increase its competitiveness and create new opportunities" (Flaig et al., 2021b, p. 255). It reflects the firm's ability to drive profound changes to a given industry conditions (Jaworski et al., 2020).

Market-shaping strategy depends on the firms' ability to perceive the market and the firm's strategic intent to shape the market (Flaig et al., 2021b). That is, market-shaping strategy is related to the firms inclination to perceive and sense the market to be able to address stakeholders preferences, not just clients (Jaworski et al., 2020; Kohli & Jaworski, 1990), as well as it align firms objectives. Therefore, to be considered a market-shaping strategy, the strategy has to shape customers and/or other market players preferences, the market structure – which are the composition of actors in a market and the functions performed by them (Nenonen et al., 2019).

Shaping markets can take different forms (Jaworski et al., 2020). For example, it can be an individual initiative, or it can be a movement of different collaborating firm group with common interests (Baker & Nenonen, 2020); it can target either shaping functional and/or cultural preferences and behaviours of customers and/or other market/ecosystem actors (Humphreys & Carpenter, 2018). Due to these differences, strategic marketing literature provided some market-shaping strategies taxonomy (Flaig et al., 2021b; Jaworski et al., 2020).

For example, Jaworski et al 2020, identified four market shaping processes based on i) the number of firms enacting the market shaping process (an individual firm or a set of collaborating organizations), and ii) the content of the market that is willing to be shaped (functional – economic appeal or cultural – tastes, values, symbolism appeal). The term "market-shaping processes" is equivalent to market-shaping strategy, because they are "ways in which markets may be driven by firms depending on their vision, value proposition, internal resources, competitive environment, and external constituencies, among other considerations" (Jaworski et al., 2020, p. 150). Then, the taxonomy originates four market shaping processes described as it follows (Jaworski et al., 2020):

i) Pied piper: characterized by an individual firm targeting to influence the preferences of customers and market actors in terms of functional benefits through a technological innovation offer.

ii) Guild: understood as a set of collaborating organizations targeting to influence the preferences of customers and market actors in terms of functional benefits through a technological innovation offer.

iii) Evangelist: when an individual firm intends to influence cultural tastes, values and symbols to benefit the firm.

iv) Apostles: when a set of collaborating firm intend to influence cultural tastes, values and symbols to the group's benefit.

Flaig et al. (2021a), listed market-shaping strategies based in four outcomes of market-shaping processes. The first is market widening, understood as an expansion of the market. The second outcome is market reduction, considered the ones focused on reducing the market, for example activities delegitimization. Third, the market maintenance is the outcome of actors' efforts to maintain the current shape of a market, when deliberated activities are deployed to obstruct market change. The fourth outcome is market disruption, comprising transformation of an existing market and the creation of a new one.

Those outcomes are intrinsically related to firm's intention to defend its current position in the market – primarily linked to market maintenance and reduction outcomes, or an offensive intention to change the market dynamics – related to the market widening and disruption outcomes (Flaig et al., 2021b).

The four market-shaping strategies are associated with firms' activities (Flaig et al., 2021b). These activities are concrete manifestation of the broad-abstract-market-shaping strategies, which are listed below:

i) Market maintenance-related activities: reinforcing and encouraging the replication of routinized practices, expectations, and/or rules; creating and maintaining longstanding relationships overtime; exerting power through status; acquisition of competitors; exerting normative pressures towards conformity; and coercing other market actors trough clout.

ii) Market reduction-related activities: acquisition of market actors; increasing price point; patenting; influencing regulations; forming alliances; and building distinctions/boundaries against well-established practices.

iii) Market widening-related activities: introducing standardization; developing market infrastructure; reducing price; cognitive reframing of exchange object; creating more value for stakeholders as a whole; and pursuing deregulation.

iv) Market disruption-related activities: reconfiguration of networks; introducing radical "market creating" innovation; introducing a new value proposition; lobbing for new regulations and standards; triggering institutional change; and innovation the business model.

FIGURE 1 illustrate the Flaig, et al. (2021a) market-shaping strategy framework.

FIGURE 1 – MARKET-SHAPING STRATEGIES FRAMEWORK

Offensive Market-Shaping Strategies		**Defensive Market-Shaping Strategies**	
Market Widening	*Market Disruption*	*Market Maintenance*	*Market Reduction*
• Introduce standardization • Developing market infrastructure • Reducing price • Cognitive reframing of exchange object • Creating more value for customers and stakeholders • Pursuing deregulation	• Reconfiguration of networks • Introducing radical innovations • Introducing new value proposition • Lobbing for new regulations and standards • Triggering institutional change • Business model innovation	• Reinforcing replication of routinized practices and expectations • Developing and maintaining longstanding relationships • Exerting power through status • Acquisitions of competitors • Exerting normative pressures towards conformity • Coercing other market actors through clout	• Acquiring market actors • Increasing price point • Patenting • Influencing regulations • Forming alliances • Building distinctions/boundaries against well-established practices

SOURCE: adapted from Flaig et al. (2021a).

This research will focus on market disruption strategy activities, specifically reconfiguration of networks and introducing radical innovations, the last already treated in previous sections. The reason to focus on reconfiguration of networks aspect is because networks have been considered as a relevant aspect of strategic marketing domain (Achrol & Kotler, 1999; Hult, 2011; R. Varadarajan, 2010) and because networks are essential to the theoretical lenses in this study (Nelson & Winter, 1977; Nenonen & Storbacka, 2018).

2.3.2 Collaboration networks in market-shaping strategy

Network is an essential concept in Systems Theory (Giesler & Fischer, 2017) , which fundaments both theoretical lenses in this study, the Evolutionary Theory of Innovation (Nelson & Winter, 1977) and Market-shaping (Nenonen & Storbacka, 2018). This central role is due to the comprehension about markets. Both theories understand that markets are formed by systems

of diverse sizes and levels, formed by networks of actors and resources, in interdependent iteractions (Möller et al., 2020; Perez, 2010). When focusing on specific market actors, being embedded in a set of nested, multi-layered and transitional network is an assumption (Möller et al., 2020; Perez, 2010; Schumpeter, 1997).

Strategic marketing literature also manifested this comprehension in some theoretical constructions (Achrol & Kotler, 1999; Hult, 2011; Shaw, 2020) and also concern about networks due to their contribution to value creation (Achrol & Kotler, 1999; Vargo & Lusch, 2004, 2017). Usually, strategic marketing literature explore networks as a manner of firms do deal with resource limitation (Costa & Didonet, 2020). That is, this stream usually focus on networks as set of linkages between market actors that can be managed to access resources, knowledge and other resources they need, without the necessity to acquire or to commit in developing them. In this realm, researchers investigated concepts such as (strategic) alliances (Fang, Lee, Palmatier, & Guo, 2016; P. R. Varadarajan & Cunningham, 1995), relationship marketing (Hunt, Arnett, & Madhavaram, 2006; J. Sheth, 2017), network capability (Costa & Didonet, 2020; O'Toole & McGrath, 2018), social media networks (Kupfer, Pähler vor der Holte, Kübler, & Hennig-Thurau, 2018; Tiago & Veríssimo, 2014) and collaboration cooperation (Baker & Nenonen, 2020; Thornton, Henneberg, & Naudé, 2013).

Considering the theoretical background in this research, networks are defined as a set of linkages of organizations and resources in a net configuration of interaction and interdependency (Möller et al., 2020). The resources can be human, financial, geographic or relational, and when the relevant ones are mobilized creating new linkages they enable firms to increase the success in market-shaping endeavours (Nenonen et al., 2019).

The linkages are an assumption of networks constituting markets, however firms can proactively engage in changing those linkages to change the market in their favour (Gulati et al., 2000). This characteristic of deliberately orchestrate the organizational linkages make networks a strategic aspect firms can rely on to achieve their objectives (Haider & Mariotti, 2016; Torkkeli et al., 2016), beyond the access to resources they do not possess.

Further, firms might establish collaboration networks to create new linkages (Baker & Nenonen, 2020). Different from transactional networks, which are motivated just by the transactional change between market actors, the collaborative networks are based on cooperation activities with a win-win synergistic outcome (A. F. Maciel & Fischer, 2020). That is, actors pertaining to that network mostly are beneficiated by being part of it, and relationships are imbued of trust and credibility building (Kindström et al., 2018; Nenonen et al., 2019). Engaging in collaboration networks might leverage the organization's knowledge, helping to

anticipate market opportunities and developing and right-timing innovation releases (Zacca et al., 2015).

Collaboration networks are set of cooperative activities with clients, suppliers and high educations and government institutions (Möller et al., 2020; OECD & Eurostat, 2018). The collaboration with clients might be a fruitful source of new ideas for innovation (Di. Kafetzopoulos et al., 2021), while clients hope to have their needs and desires achieved more effectively. While collaborating with suppliers, organizations are motivated by improving quality and reducing production costs (Di. Kafetzopoulos et al., 2021), while the suppliers can benefit from a closer relationship with its business customer. Then, cooperation activities with higher education and government institutions can promote access to new technologies (Walter et al., 2006) or influence emerging norms and regulations (Möller et al., 2020), while the universities and research institutes can commercialize and profit from its innovation (Walter et al., 2006) and government institutions might increase internal innovation (McKelvey & Saemundsson, 2018). Based on the above-mentioned assumptions, this research assumes collaboration networks as a market-shaping strategy.

2.4 RESEARCH HYPOTHESES

2.4.1 Market dynamics and innovation relationship

The Evolutionary Theory of Innovation states that there is an iteration between the environment and innovation release (Schumpeter, 1997). This relationship is classified as iteration because it is not a one-way linear relationship of interaction, because market dynamics influence innovation and innovations can affect the market dynamics (Nelson & Winter, 1977; Tigre, 2009). It is not a tautology, though. Evidences depart from a determined scenario or event influencing subsequent innovation, which might trigger changes in the environment (Filippetti et al., 2020; Vlados et al., 2021). In other words, the market dynamics condition innovation release, which, by its turn condition subsequent market dynamics.

Other theoretical lens used to conduct this study is market-shaping research. Even though market-shaping research is focused on understanding the organization's proactive actions to shape markets in their benefit, this theoretical approach also states that organization's proactive actions are conditioned to the organization's market perceptions (Flaig et al., 2021b; Jaworski et al., 2020) and the concurrence of opposite strategies in the market (Nenonen et al., 2019; Vargo et al., 2023). It means that market shaping approach also consider environment as a condition to organization's decision, e.g. decision whether to develop a new technology. To

introduce radical innovation, which is capable to change the market, depends on organization intention to deliver the new technology and modify the market dynamics, and also what was its perception about the environment landscape (Flaig et al., 2021b).

Commonly, the empirical studies are designed to explore market dynamics as moderator of a main relationship involving innovation (Rousseau et al., 2016; Tang et al., 2021; Yu et al., 2014) or a control variable (Chandy & Tellis, 1998). However, the theoretical lenses used in this study lead to infer that environmental aspects, in this case market dynamics, could act as antecedents to innovation. Nevertheless, the moderation statements provide some insights about the fundamentals of market dynamics acting as innovations antecedents.

In this context, the argument of competitive intensity as moderator is that, when competition is high/intense, firms are forced to differentiate from competitors to survive or maintain their competitive advantage. Moreover, innovation is seen as a manner of firms to respond market pressures and increase differentiation is by launching new products or services (Tang et al., 2021). From the technological turbulence aspect, the core argument of the proposition of moderation is that rapid changes in technologies turns current products and services obsolete (Yu et al., 2014). Therefore, firms are stimulated to continuously develop and introduce new products (Rousseau et al., 2016; Tang et al., 2021).

However, there are some studies that consider market dynamics as antecedents (Hughes & Chandy, 2021; Ojha et al., 2020). For example, Hughes and Chandy (2021) reinforce historical-context of the environment dynamics by documenting longitudinally environmental landscapes, such as new technology releases, patterns of customer behaviour and competitors dynamics (Hughes & Chandy, 2021). In this sense, results showed that the more intense is the market change, the more firms will rely on innovation to maintain their competitive advantage, guaranteeing their survival and/or overcome regarding competitors (Hughes & Chandy, 2021). Another example is Ojha et al. (2020) study that agued market dynamics as innovation antecedents to explain innovation speed, which is the velocity of innovation introduction in the market. The argument to sustain this relationship of market dynamics impacting on innovation relies on resource-based view, stating that environment turbulence induces firms to innovate faster to achieve and sustain competitive advantage (Ojha et al., 2020). In this case, competitive intensity was found to influence innovation speed negatively, and technological turbulence was not significant. However, both aspects of market dynamics, i.e. competitive intensity and technological turbulence, were associated with market turbulence, defined as the change in customer needs. Moreover, effects were also analysed individually and were positively significant , indicating that market turbulence cannibalize the

effect of competitive intensity and technological turbulence, being the customers a representative influence in innovation speed (Ojha et al., 2020).

Therefore, it is inferred that the higher the levels of competitive intensity and technological turbulence, the more firms will be motivated to introduce radical innovation in the market.

Based on the aforementioned, it is proposed:

Hypothesis 1: Market dynamics positively relates with radical innovation.

2.4.2 Collaboration networks and radical innovation relationship

Both, Evolutionary Theory of Innovation and Market shaping approach, called as lens for this study, view organizations as embedded in a set of networks, nested, multi-layered and transitional (Flaig et al., 2021b; Möller et al., 2020; Perez, 2010; Schumpeter, 1997). That means that linkages between market actors change over time and organizations can choose when, to whom and by which means they want build relationships (O'Toole & McGrath, 2018). Given the complexity of markets being nested and multi-layered, take the right decision about networks is strategic, it can affect organization's survival and enable it to achieve its objectives (Gulati et al., 2000; Ritter & Gemünden, 2003). In this research, the different linkages the organizations can develop to deliver innovation are analysed.

Literature in supply chain field investigates how links with suppliers can boost innovation. Once suppliers are in charge of providing inputs to organization, choosing the right ones might introduce new technology of materials, components and systems (Yu et al., 2014). When considering literature on global value chain (GVC), there is a research corpus, which defends that participating on global value chain, that is, having international partners, would boost innovation (Antràs, 2020; Genc et al., 2019). The argument behind this statement is that having foreign partners permits the firm to access different knowledge and technology, creating a potential to new technology release (Antràs, 2020; Genc et al., 2019). Considering the theoretical lenses used in this research (Nelson & Winter, 1977; Nenonen & Storbacka, 2018), the second body of research – which affirms that having international partners favour innovation – is more adherent to the idea that the environment influence firm decisions.

Regarding the link between firms and higher educational studies, the literature about spinoffs provides empirical evidences (Mira-Solves et al., 2021). According to spinoff literature, i.e. innovations emerging from universities, collaboration between firms, universities enable the new and disruptive technologies (Walter et al., 2006). Even though this literature *corpus* provide insights on innovation developed in universities, it provides arguments about

the partnership between universities and other organization such as firms to share knowledge and resources to guarantee the success of innovation (Mira-Solves et al., 2021). In this sense, the universities nurture the relationship with technological discovering and predicting technological tendencies, while firms provide resources such as financial ones and market knowledge (Walter et al., 2006; Yu et al., 2014).

Another part pertaining to firm's network that have been studied to play a role favouring innovation are the government institutions. This relation takes form in initiatives to favour some connections between actors present in the system (Munksgaard & Medlin, 2014), i.e. universities, research institutes and others, or supporting and funding the innovation development through public policies (Roper & Turner, 2020).

Finally, the client linkages also might enable innovation for some reasons. First, innovation are differed from inventions due to the utility they have to a certain public, clients or businesses, including the firm itself (OECD & Eurostat, 2018). Therefore, straightening relationship with clients might help to get information about theirs needs and wants to increase the probability to develop innovation that are valuable to clients (Efrat et al., 2017). Second, clients can provide some disruptive ideas, which might serve as input to developing innovation (D. Kafetzopoulos & Skalkos, 2019).

Given the exposed, it is hypothesized that:

Hypothesis 2: Collaboration networks positively relates with radical innovation.

2.4.3 Complementarity of market dynamics and collaboration networks influence on radical innovation

Evolutionary Theory of Innovation and Market Shaping Approach consider different levels of market systems that are nested, multi-layered and transitional (Flaig et al., 2021b; Möller et al., 2020; Perez, 2010; Schumpeter, 1997). Once organizations are embedded in this nested combination of systems, it is inferred by this research that each layer has its own impact on radical innovation and together they might be combined to increase the explanation of radical innovation.

Market shaping literature propose to understand the interaction between market levels in providing innovation. The argument relies on understanding that innovation follows a value-crating system, which comprises the integration of resources between different levels of the market (Windahl, Karpen, & Wright, 2020). The market levels assignment is arbitrary, i.e. market dynamics seen as macro-level and relationship with other players at meso-level, but

literature advocate that in practice actions that happen in one level usually relates with other levels (Windahl et al., 2020). Therefore, to understand deeply how phenomena behave considering the markets as nested, multi-layered and transitional, it is necessary to combine different levels.

Evidence of collaboration and environmental dynamics as drivers to firm innovation, found that both act as innovation antecedents (D. Kafetzopoulos & Skalkos, 2019). However, the evidence did not explore if collaboration networks and market dynamics elements present a complementary behaviour, e.g. if the antecedents explain better innovation than their individual effects or if they actually interacts to explain innovation.

Another literature evidence, comprising qualitative empirical study, demonstrated that introducing new technologies capable of shaping the market involves four mechanism (Peters et al., 2020). The first mechanism is the firm's culture of being aware of climate change, that is, sense environment changes and creating and dissipating mental models. Usually the firms develop this culture to track for environmental threats, or when there is an eminent market bifurcation to happen, e.g. a new regulation (Peters et al., 2020). The second mechanism is due to adherence to customers' practice, adapting the offer to the consumers and create an open building offer (Peters et al., 2020). The third mechanism is related to the firm's effort to pacify the industry hostility, creating intra- and inter-system harmonious interactions (Peters et al., 2020). The four mechanism is about reinforcing and balancing feedbacks, i.e. creating loops of feedback to system through investments and awards to reinforce the mental models from the sensing in mechanism one and reduce the friction of the new open building offer (Peters et al., 2020). Then this qualitative study, by mapping the mechanisms to shape markets through introducing new technologies, advocate that sensing the market changes motive firms to innovate, and straightening the relationship with clients and other players in the industry are mechanisms for the firm's success on shaping markets with innovation.

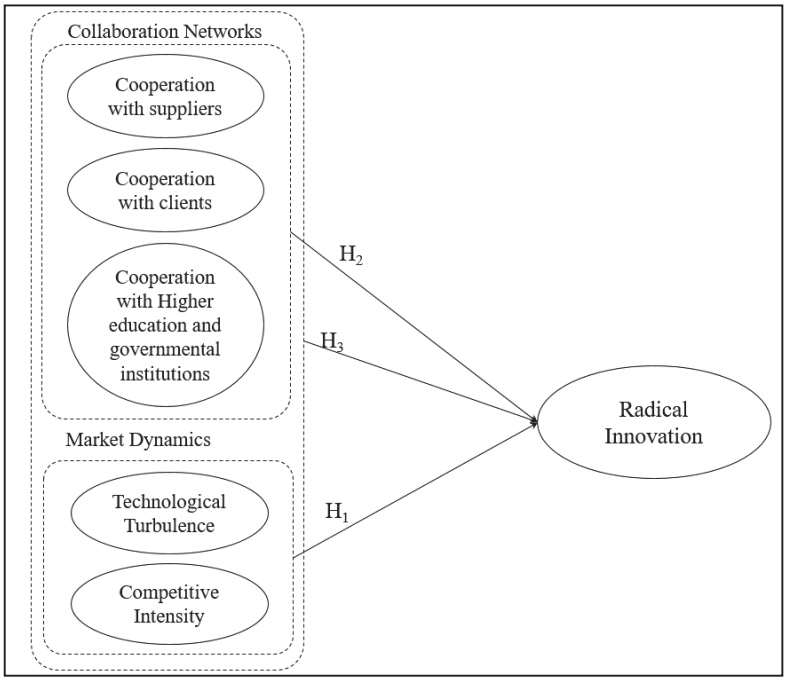
These literature evidences show two different manners to approach the different market layers, i) the conjoint effect or effect together, when the argument rely that two or more elements together explain better innovation than the elements alone (D. Kafetzopoulos & Skalkos, 2019), and ii) the interaction effect, when different market layers interacts and produce an unique effect on innovation (Peters et al., 2020). Deepening into these differences permits literature to scrutinize the relationship between the market and innovation and approximate theoretical frameworks and evidences to reality.

Given the exposed, it is hypothesized that:

Hypothesis 3: The complementarity between market dynamics and collaboration networks positively relates with radical innovation.

FIGURE 2 represents the hypotheses scheme.

FIGURE 2 – HYPOTHESES SCHEME



SOURCE: The author, 2025.

3 METHODOLOGICAL PROCEDURES

3.1 RESEARCH DESIGN

This research follows a hypothetic-deductive logic based on a positivistic epistemology. Secondary data are used to test hypotheses. The hypotheses test used regression-based statistics, merging panel data analysis (Colonescu, 2016; Henningsen & Henningsen, 2019) with hierarchical regression (Hair Jr., Hult, Ringle, & Sarstedt, 2014), Therefore, this research is primarily confirmatory (Malhotra, 2010). Data were analysed using Excel sheets and R statistical software.

3.1.1 Hypotheses specification

The previous chapter described the theoretical foundation, which based the hypotheses proposition. The discussion originated the hypotheses presented in TABLE 2, and their respective theoretical foundation.

TABLE 2 – RESEARCH HYPOTHESES

Hypothesis	Theoretical foundation
H1: Market dynamics positively relates with radical innovation.	(Hughes & Chandy, 2021; Ojha et al., 2020; Tang et al., 2021; Yu et al., 2014)
H2: Collaboration networks positively relates with radical innovation.	(Antràs, 2020; Efrat et al., 2017; Genc et al., 2019; Gulati et al., 2000; D. Kafetzopoulos & Skalkos, 2019; Mira-Solves et al., 2021; Munksgaard & Medlin, 2014; Ritter & Gemünden, 2003; Roper & Turner, 2020; Walter et al., 2006; Yu et al., 2014)
H3: The complementarity between market dynamics and collaboration networks positively relates with radical innovation.	(Flaig et al., 2021b; D. Kafetzopoulos & Skalkos, 2019; Möller et al., 2020; Perez, 2010; Schumpeter, 1997; Windahl et al., 2020)

SOURCE: The author, 2025.

3.2 VARIABLES DEFINITIONS

The research was developed considering three main concepts: market dynamics, collaboration networks and radical innovation. Therefore, it is provided the constitutive and operational definition of each concept. Once the variables are based on panel data, all the variables received the difference from the lagged value treatment, e.g. the variable in time t is the difference between the value recorded in time t minus the value recorded in time t-1, in an attempt to minimize serial correlation issues (Colonescu, 2016). The equation I represents the treatment the variables received, which impact on operational definition.

$$X_i = X_t - X_{t-1} \quad \text{(I)}$$

The variable X_i is the value of the variable X in the period i. The variable X_t is the value of the variable X in the period t. The variable X_{t-1} is the value of the variable X in the period before period t.

Market Dynamics:

Constitutive definition: Market dynamics are the environmental changes. The environment is an ecosystem of actors and pressures in constant interaction to coevolution (Baker & Nenonen, 2020). Ecosystems are complex contexts consisting in nested systems composed by diverse interacting elements, which interactions are nonlinear (Möller et al., 2020).

Operational definition: Market dynamics concept was operationalized by two measures, to capture the effect of two aspects of the environment: competitive intensity and technological turbulence.

i) Competitive intensity: the difference of the percentage of firms that affirmed that introduced new product or process ongoing or abandoned innovation or organizational or marketing innovation between two subsequent periods in the sample (OECD & Eurostat, 2005).
ii) Technological turbulence: the difference of the percentage of firms that affirmed that introduced new product or process (technological innovation) two subsequent periods in the sample (OECD & Eurostat, 2005).

Collaboration Networks:

Constitutive definition: Collaboration networks are a set of cooperative activities with clients, suppliers and high educations and government institutions to innovation (Möller et al., 2020; OECD & Eurostat, 2018).

Operational definition: Collaboration networks concept was operationalized by three measures, individualizing the effect of each linkage (OECD & Eurostat, 2005).

i) Cooperation activities with clients: The difference of the percentage of firms that affirmed that have engaged in cooperation with clients between two subsequent periods in the sample.

ii) Cooperation activities with suppliers: The difference of the percentage of firms that affirmed that have engaged in cooperation with suppliers between two subsequent periods in the sample.
iii) Cooperation activities with higher education and government institutions: The difference of the percentage of firms that affirmed that have engaged in cooperation with higher education and government institutions between two subsequent periods in the sample.

Radical Innovation:

Constitutive definition: Radical innovation is considered a new product or process, result of environmental turbulence, institutional pressures, organizational culture and processes, inter-organizational interaction and/or resource allocation, which is available for use and/or consumption (Garcia & Calantone, 2002; Harmancioglu et al., 2009; OECD & Eurostat, 2018; Ojha et al., 2020).

Operational definition: The difference of the percentage of firms that affirmed that developed products or processes that are new to the market between two subsequent periods in the sample (Saridakis, Idris, Hansen, & Dana, 2019).

Control variables:

The control variables available in the database, were selected because previous studies already explored the Gross Domestic Product (GDP) influence in innovation, and that pertaining to developed or emergent countries group explained innovation differences between countries (Genc et al., 2019; Reddy, Chundakkadan, & Sasidharan, 2020; Sarwar et al., 2021; Shankar & Narang, 2020). The reason to control for GDP is because innovation development depends on resources allocation to this end, and the higher the resources availability by means of higher GDP, the higher the probability the country would invest on innovation or element that favour it (Sarwar et al., 2021). Regarding pertaining to emergent countries group, the arguments are two-way. One stream advocate that emergent countries lack of resources might harness them to engage in innovation. The other stream emphasize that the limitation of resources stimulate emergent countries to find creative solutions and to overcome the economic differences through internationalization, importing knowledge and accessing resources they lack (Genc et al., 2019; Shankar & Narang, 2020).

Gross Domestic Product (GDP):

Constitutive definition: GDP measures all the output generated by a country in a given period of time, e.g. the monetary value of all goods and services produced within the borders of a country in a period (Callen & Jahan, 2024).

Operational definition: difference of the GDP logarithm between two subsequent periods in the sample.

Emergent country:

Constitutive definition: Emerging countries are the ones characterized as emerging markets, which are evaluated after their:

i) systemic presence, evaluated by the size of the countries' economy (nominal GDP), the population, and their share of global trade exportation;
ii) market access, which is the countries' external debt share in global external debt, as well as countries inclusion in global indexes used by large international institutional investors and the frequency and amount of international bonds issued;
iii) income level, assessed by countries' GDP per capita in nominal US dollars (Duttagupta & Pazarbasioglu, 2021).

Operational definition: dummy variable were 1 was considered emergent and 0 non-emergent country ("Country Composition of WEO Groups," 2023).

TABLE 3 summarizes the variables definition.

TABLE 3 – VARIABLES DEFINITION SUMMARY

Concept	Constitution definition	Operational definition
Market dynamics	Market dynamics are the environmental changes, which are understood as ecosystems. Ecosystems are complex contexts consisting in nested systems composed by diverse interacting elements, which interactions are nonlinear (Möller et al., 2020).	i) Competitive intensity: the difference of the percentage of firms that affirmed that introduced new product or process ongoing or abandoned innovation or organizational or marketing innovation between years (OECD & Eurostat, 2005). ii) Technological turbulence: the difference of the percentage of firms that affirmed that introduced new product or process (technological innovation) between years (OECD & Eurostat, 2005).
Collaboration networks	Collaboration networks are a set of cooperative activities with clients, suppliers and high educations and government	i) Cooperation activities with clients: The difference of the percentage of firms that

	institutions to innovation (Möller et al., 2020; OECD & Eurostat, 2018).	affirmed that have engaged in cooperation with clients between years. ii) Cooperation activities with suppliers: The difference of the percentage of firms that affirmed that have engaged in cooperation with suppliers between years. iii) Cooperation activities with higher education and government institutions: The difference of the percentage of firms that affirmed that have engaged in cooperation with higher education and government institutions between years.
Radical Innovation	Radical innovation is considered a new product or process, result of environmental turbulence, institutional pressures, organizational culture and processes, inter-organizational interaction and/or resource allocation, which is available for use and/or consumption (Garcia & Calantone, 2002; Harmancioglu et al., 2009; OECD & Eurostat, 2018; Ojha et al., 2020).	The difference of the percentage of firms that affirmed that developed products or processes that are new to the market between periods (Saridakis et al., 2019)
Gross Domestic Product (GDP)	GDP measures all the output generated by a country in a given period of time, e.g. the monetary value of all goods and services produced within the borders of a country in a period (Callen & Jahan, 2024).	The difference of the GDP logarithm between periods.
Emergent country	Emerging countries are the ones characterized as emerging markets, which are evaluated after their: i) systemic presence, evaluated by the size of the countries' economy (nominal GDP), the population, and their share of global trade exportation; ii) market access, which is the countries' external debt share in global external debt, as well as countries inclusion in global indexes used by large international institutional investors and the frequency and amount of international bonds issued; iii) income level, assessed by countries' GDP per capita in nominal US dollars (Duttagupta & Pazarbasioglu, 2021).	Dummy variable were 1 is considered emergent and 0 non-emergent country ("Country Composition of WEO Groups," 2023).

3.3 POPULATION AND SAMPLE

The Business Innovation Statistics and Indicators from the Organisation for Economic Co-operation and Development) (hereafter OECD) were the data source of this research. OECD is a "forum and knowledge hub for data, analysis and best practices in public policy" (OECD, 2024). Specifically, data consolidated from Regional Innovation Surveys were collected from OECD iLibrary. Innovation surveys are run in diverse countries based on Oslo Manual, which provide some guidelines about how to search innovation, in an attempt to unify understanding

about innovation theme and enable to collect data to support decision making to provide countries development (OECD & Eurostat, 2005, 2018).

Therefore, OECD unify data collected from countries to generate insights about innovation and countries development (OECD & Eurostat, 2005).Then this research data analysis is based on regional innovation surveys from Business Innovation Statistics and Indicators data, which are organized in waves comprising 2 to 3 years and consolidated by country. The waves available for downloading in OECD iLibrary were: 2013, 2015, 2017, 2019, 2021 and 2023. OECD collected data from OECD members and other few non-members. APPENDIX I presents the summary of countries included in the databases in each wave, as well as the range of time of each wave in the data collection. Additionally, each wave originated different reports, considering the OECD interests and societal demands, leading to the inclusion of different indicators set in each wave. Therefore, each database were analysed to properly pair the indicators in a sense that they could be related and conjointly analysed. APPENDIX II presents the schema of indicators pairing in each wave.

3.3.1 Sample delimitation

After merging the waves databases, creating a consolidated one, and analysing each indicator, it was highlighted that 2021 and 2023 waves have significant differences regarding indicators included. The difference was due to the new Oslo Manual edition from 2018. In this version, OECD slightly changed the comprehension about innovation concept. The previous version (2005) understood the innovation as the implementation of a new and/or improved product, process, marketing methods and/or organizational method in business practices, workplace or external relations (OECD & Eurostat, 2005). The current version of the manual defines innovation as a new and/or improved product or process, or the combination thereof, that is significantly different from previous products and processes, and has been made available to potential users or brought into use (OECD & Eurostat, 2018). These differences might lead to new organization of indicators between waves, hampering the relation between 2013, 2015, 2017 and 2019 data and 2021 and 2023 data. Therefore, the first exclusion criteria was time, which excluded waves 2021 and 2023 waves' data.

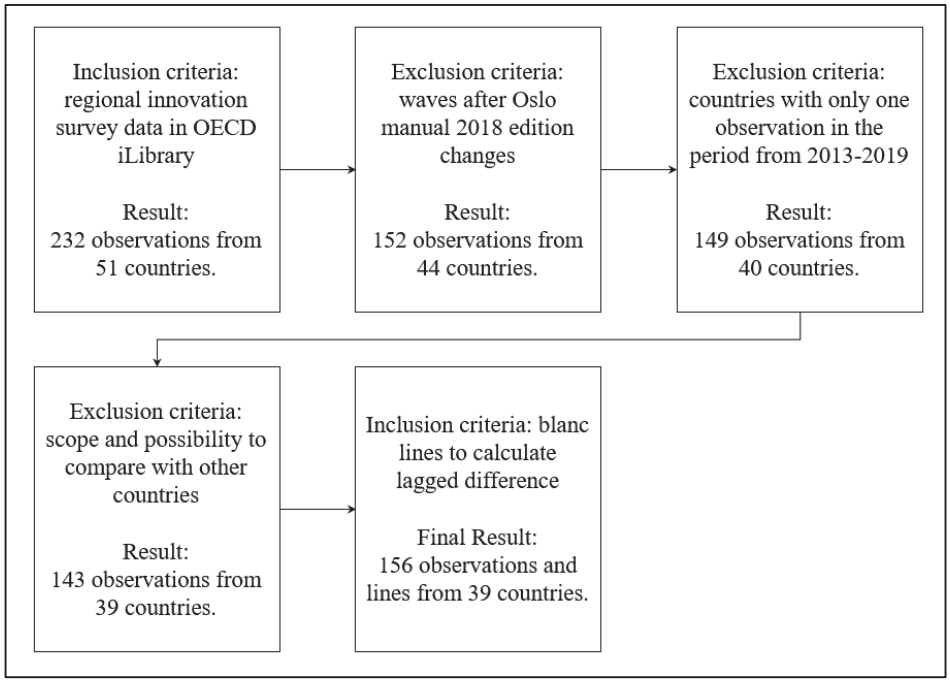
The second exclusion criteria was the countries that have been registered in less than two waves, because the variables were calculated from lagged differences. In this case, having registration in just one wave is equal then having no registration. The third exclusion criteria was analysing the scope of the observation and the possibility to compare it with other countries.

In this sense, data from Colombia contains data from manufacture and services, separately, with no possibility to merge. Therefore, data from Colombia were excluded.

Finally, some countries did not present information for every wave. Therefore, blank lines were added to permit to calculate the difference from lagged variables to compose the variables as they were defined in the previous section.

FIGURE 3 demonstrate the sampling criteria over the consolidated database.

FIGURE 3 – SAMPLING CRITERIA



SOURCE: The author, 2025.

3.3.2 Sample characteristics

The sample was composed of 39 countries. From these, 8 (20.5%) were considered emergent and 31 (79.5%) non-emergent ("Country Composition of WEO Groups," 2023). The high concentration on non-emergent countries was due to the OECD ownership over data. OECD data usually focus on its members' nation data, which are mostly developed. TABLE 4 demonstrates the cross-table distribution of emergent and non-emergent countries in continents.

TABLE 4 – COUNTRIES CROSS-TABLE OF EMERGENTE AND NON-EMERGENT COUNTRIES IN CONTINENTS

	America	Asia	Europe	Oceania
Emergent	3 (7.7%)	2 (5.1%)	3 (7.7%)	0 (0.0%)
Non-emergent	2 (5.1%)	3 (7.7%)	24 (61.5%)	2 (5.1%)

SOURCE: The author, 2025.

TABLE 4 demonstrates that besides the concentration of countries on non-emergent countries, data were mostly from European countries, in line with OECD members composition. TABLE 5 presents the radical innovation mean in each continent by period wave. The column 2013 and 2015 were not applicable because information about the implementation of products and processes that are new to the market, e.g. indicator that served as proxy for radical innovation measurement, were collect just in 2015 wave, as evidenced in APPENDIX II. Once proxies were built as lagged difference variables, 2013 and 2015 waves were computed as missing values for this variable.

TABLE 5 – RADICAL INNOVATION MEAN BY CONTINENT AND WAVE

	Wave 2013	Wave 2015	Wave 2017	Wave 2019
America	NA	NA	-9.841	2.755
Asia	NA	NA	-3.466	0.369
Europe	NA	NA	0.381	1.900
Oceania	NA	NA	7.029	0.988
Missing values	39	39	6	5

SOURCE: The author, 2025.
NA: Not applicable.

Analysing TABLE 5, it is possible to note that American, Asian and European nations' businesses in the sample present increase in radical innovation from 2017 to 2019 waves, while Oceania nations' businesses presented a decrease in radical innovation mean. Businesses from American countries in the sample had the highest positive variation in radical innovation mean. TABLE 6 presents market dynamics elements, e.g. competitive intensity and technological turbulence by continent and period wave. The reason there are "not applicable" value in 2013 is that variables were treated as lagged difference variables. The 2015 wave in technological turbulence also received "not applicable" because the item of the percentage of businesses that implemented technological turbulence, which served as the basis for this proxy, was present in the OECD datasets just in 2015.

TABLE 6 – MARKET DYNAMICS ELEMENTS MEANS BY CONTINENT AND WAVE

	Competitive intensity				Technological turbulence			
	2013	2015	2017	2019	2013	2015	2017	2019
America	NA	-24,739	-3,154	-33,542	NA	NA	-20,128	-14,922
Asia	NA	-8,363	-6,448	-8,936	NA	NA	-2,348	-2,066
Europe	NA	-7,011	0,827	-0,913	NA	NA	0,847	2,627
Oceania	NA	-26,691	2,209	-5,793	NA	NA	-1,335	4,463

Missing values	39	7	7	4	39	39	9	6

SOURCE: The author, 2025.
NA: Not applicable.

Regarding TABLE 6, it is possible to verify that all continents presented the same tendency in competitive intensity mean, increasing from 2015 to 2017 and decreasing again in 2019. About technological turbulence mean, all continents increased the variation of firms affirming to have implemented new products and processes, that is, increasing technological turbulence from 2017 to 2019. TABLE 7, TABLE 8and TABLE 9 present the collaboration networks linkages by continent and waves. The "not applicable" values for 2013 in every element of collaboration networks are due to the lagged difference treatment.

TABLE 7 – COOPERATION WITH SUPPLIERS MEANS BY CONTINENT AND WAVE

	Cooperation with suppliers			
	2013	2015	2017	2019
America	NA	-2,050	0,599	-3,006
Asia	NA	-7,155	-5,803	-7,603
Europe	NA	0,283	1,679	0,168
Oceania	NA	-8,399	1,354	2,118
Missing values	39	7	8	4

SOURCE: The author, 2025.
NA: Not applicable.

TABLE 7 presents that cooperation with suppliers' means from almost all continents varied in a tendency to increase competition from 2015 to 2017 and a decrease from 2017 to 2019 waves. The exception was Oceania, which tendency in cooperation with suppliers was to increase the percentage of firms affirming to establish cooperation activities with suppliers to innovate.

TABLE 8 – COOPERATION WITH CLIENTS MEANS BY CONTINENT AND WAVE

	Cooperation with clients			
	2013	2015	2017	2019
America	NA	0,447	1,566	-5,182
Asia	NA	-6,535	-11,079	-5,810
Europe	NA	-2,330	-3,628	1,483
Oceania	NA	-6,155	-3,578	2,522
Missing values	39	7	11	7

SOURCE: The author, 2025.
NA: Not applicable.

TABLE 8 organizes the cooperation activities with clients' means. Asia and Europe presented the same behaviour decreasing the variation of firms that engaged in cooperation activities for innovation with clients from 2015 to 2017 and increase from 2017 to 2019. America presented an increase from 2015 to 2017 and decrease from 2017 to 2019. Finally, Oceania presented increase from 2015 to 2017, and then increase again from 2017 to 2019.

TABLE 9 – COOPERATION WITH HIGH EDUCATION AND GOVERNMENT INSTITUTIONS MEANS BY CONTINENT AND WAVE

	Cooperation with high education and government institutions			
	2013	2015	2017	2019
America	NA	-0,400	-0,199	-6,731
Asia	NA	-7,044	-8,910	-7,159
Europe	NA	-0,357	-1,183	-0,969
Oceania	NA	-5,543	NA	1,039
Missing values	39	9	11	6

SOURCE: The author, 2025.
NA: Not applicable.

Analysing TABLE 9, which presents the cooperation activities with high education and government institutions to innovation, it is possible to verify that Asia and Europe presented the same behaviour decreasing the variation of firms that affirm to engage this type of activities from 2015 to 2017 and a decrease from 2017 to 2019. America firm's variation increased from 2015 to 2017 and decreased from 2017 to 2019. Oceania presented a "not applicable" value in 2017, because Oceania's countries did not registered values for the percentage of firms that established cooperation activities to innovation with high education and government institutions to innovation in 2015 in the dataset. However, that was an increase in the variation of the percentage of firms engaging in this type of activity.

The next section elucidates data analysis technique.

3.4 DATA ANALYSIS TECHNIQUE

3.4.1 Missing values

Missing values are a common issue when dealing with secondary data. A usual treatment to missing data is to exclude them. However, treating missing values by exclusion was not viable for this study without hampering the sample size. TABLE 10 organizes the variables indicating the volume of missing value and missing value rates by variable, except control variables.

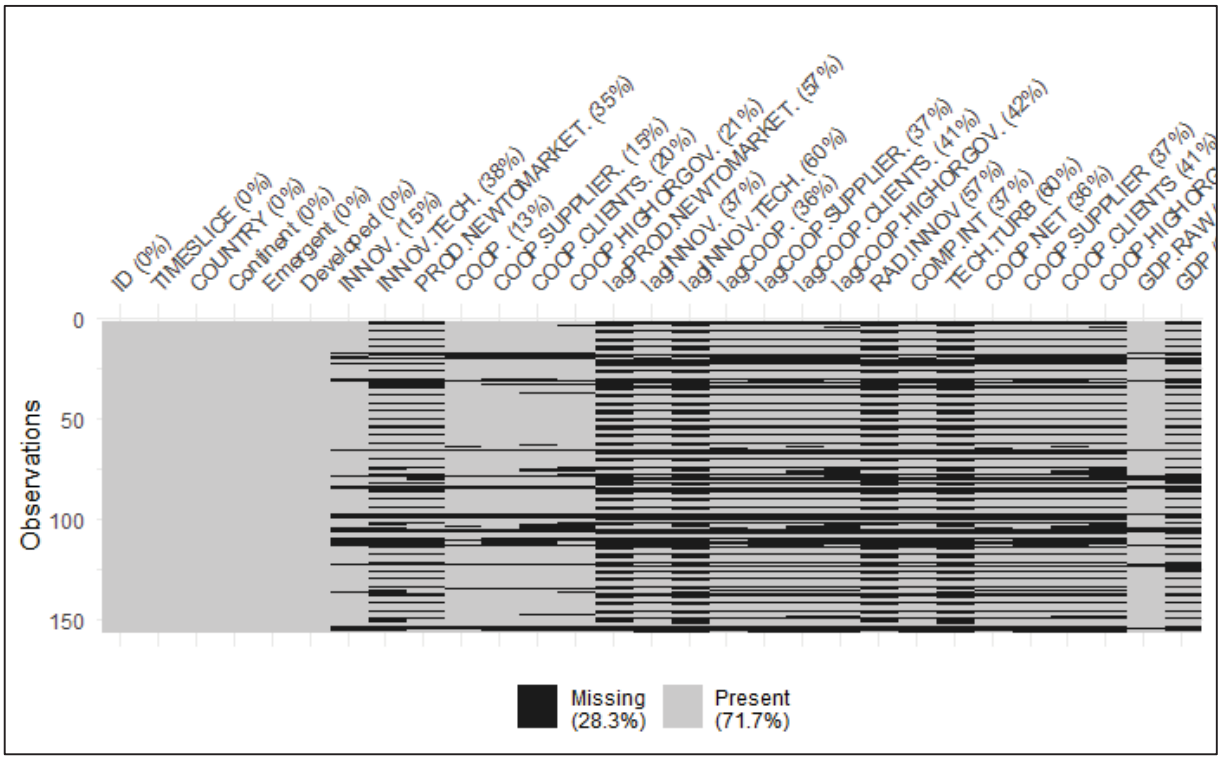
TABLE 10 – MISSING VALUE RATES BY VARIABLE

Variable	Index	Missing value	Missing value rate (%)
Competitive intensity	COMP.INT	57	36,5
Technological turbulence	TECH.TURB	93	59,6
Cooperation activities to innovation with Clients	COOP.CLIENTS	64	41,0
Cooperation activities to innovation with Suppliers	COOP.SUPPLIER	58	37,2
Cooperation activities to innovation with Higher education and public institutions	COOP.HIGHORGOV	65	41,7
Radical Innovation	RAD.INNOV	89	57,1

SOURCE: The author, 2025.

TABLE 10 confirms the high rates of missing values in data, common to secondary data studies (Young & Johnson, 2015). After that, missing data rates were further investigated to assess possible biases sources. To accomplish that, graphical analysis was used to visualize patterns of missing data. It consists of constructing a matrix highlighting missing data with a different colour (FIGURE 4).

FIGURE 4 – MISSING VALUES GRAPHICAL ANALYSIS



The FIGURE 4 refers to the visual analysis of missing values to verify if they present random or a systematic distribution. It was possible to verify that missing values increased in

lagged variables and the calculated variables (lagPROD.NEWTOMARKET, lagINNOV, lagINNOV.TECH, lagCOOP, lagCOOP.SUPPLIER, lagCOOP.CLIENTS, lagCOOP.HIGHORGOV, RAD.INNOV, COMP.INT, TECH.TURB, COOP.NET, COOP.SUPPLIER, COOP.CLIENTS, COOP.HIGHORGOV, GDP) from the difference, what was expected due to the lost of one observation. Regarding the black lines, they were also expected once blank lines were added to the database representing the countries' observations that were not collected each wave by the data source. The inclusion was needed to calculate the lagged difference variables used as proxies to this study's concepts, which were described in previous sections. Therefore, the patterns found in graphical analysis were already expected, and no other missing value pattern was identified, that is, missing values distribution approximates to random distribution, departing missing values distribution bias.

Panel data analysis is robust to manage missing data, however the volume can harm the analysis. To verify this issue it were performed some analysis to assess panel imbalance (Henningsen & Henningsen, 2019). The "pdim" function in "plm" R library identifies panel information to evidence panel balance or imbalance. This function returns the analysis units number (n), e.g. countries, time series (T), e.g. data waves, and the number of observations (N), e.g. the lines in the database. The result was 39 analysis units, 4 time series and 156 observations. This result indicates that the panel is balanced because N = n * T. However, this result was due to the inclusion of the blank lines to calculate the lagged variables to permit the lagged difference variables calculation. Then, the panel data can be classified as unbalanced panel data, because not every country data were present every wave and there are random missing data within the collected data set.

Therefore, γ (*gamma*) ($0 < \gamma \leq 1$) and υ (*nu*) ($1/n < \upsilon \leq 1$) were used to measure the panel data unbalancedness (Ahrens & Pincus, 1981), and both converging to 1 to represent perfect balancedness. To calculate them, the function "punbalancedness" was perfomed using the pooled model with the dependent variable and all exogenous variables, including control ones. This was since considering the database would return the value of 1 for *gamma* and *nu*, because the number of observations were equal the product of analysis units times time series. The test provided the values of 0.8934 for *gamma* and 0.9155 for *nu*, departing issues of missing values.

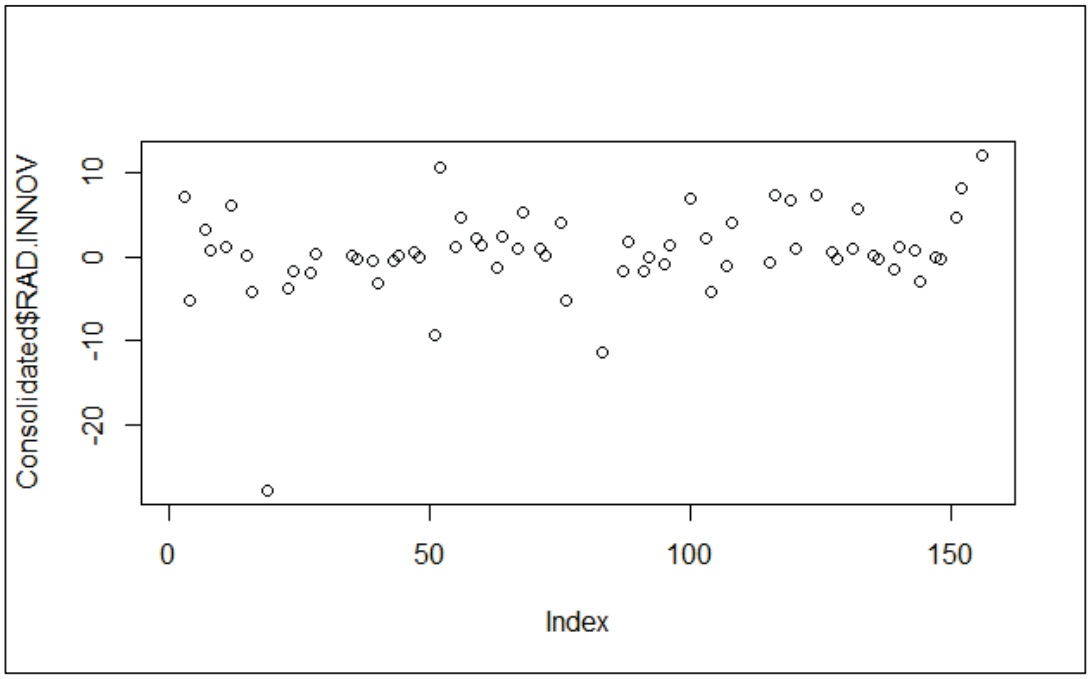
After assessing missing values, dependent variable normality test was performed.

3.4.2 Dependent variable normality test

In regression models, e.g panel data analysis and hierarchical regression, the normality test is relevant to verify biases in data distribution, mainly the dependent variable (Colonescu, 2016; Hair, Black, Babin, & Anderson, 2014). This study procedures Shapiro-Wilk normality test to verify radical innovation proxy, given by the variation of the percentage of firms that affirmed to have launched innovations that were new to the market in determined period.

Shapiro-wilk test result demonstrated that the radical innovation data is not normally distributed (p-value < 0.01). Therefore, the dependent variable distribution, e.g. radical innovation, was further investigated graphically, with scatter (FIGURE 5) and histogram (FIGURE 6) plots (Hair et al., 2014).

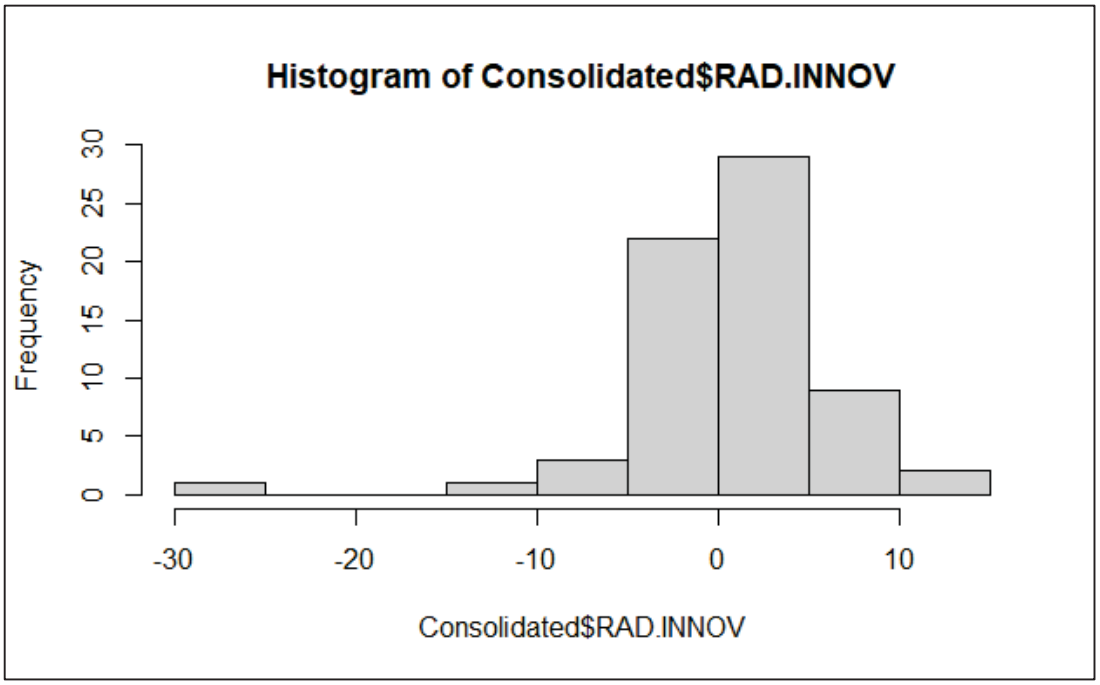
FIGURE 5 – RADICAL INNOVATION SCATTER PLOT



The FIGURE 5 presents radical innovation scatter plot. It is evidenced that the values were randomly distributed around the zero value in y-axis. This concentration around zero-value occurs because the proxy represents the variation of firms affirming to have implemented innovations, which were new to the market, between period waves. Then, it is an expected behaviour once the variable is lagged-difference-treated.

The FIGURE 6 represents the histogram of radical innovation variable. Graphically is possible to see a behaviour that is similar to a Gauss curve, but it present a slightly asymmetry to right. Therefore, radical innovation data behaviour is graphically proximate to a normal behaviour.

FIGURE 6 – RADICAL INNOVATION HISTOGRAM PLOT



Regarding normality test, literature argues that dependent variable residuals normality is even more critical to data then the values informed itself (Hair et al., 2014). Thus, if the residuals do not present normality, i.e., a random behaviour, the error of the model might presents a tendency, which indicates systemic error to the model. The residuals normality test from the dependent variable was performed considering the pooled model described after in this study. The test showed a p-value of 0.030, which was considered not a problem to the analysis, being over than 0.01. After, residuals scatter (FIGURE 7) and histogram (FIGURE 8) plots were further investigated.

FIGURE 7 – RESIDUALS SCATTER PLOT

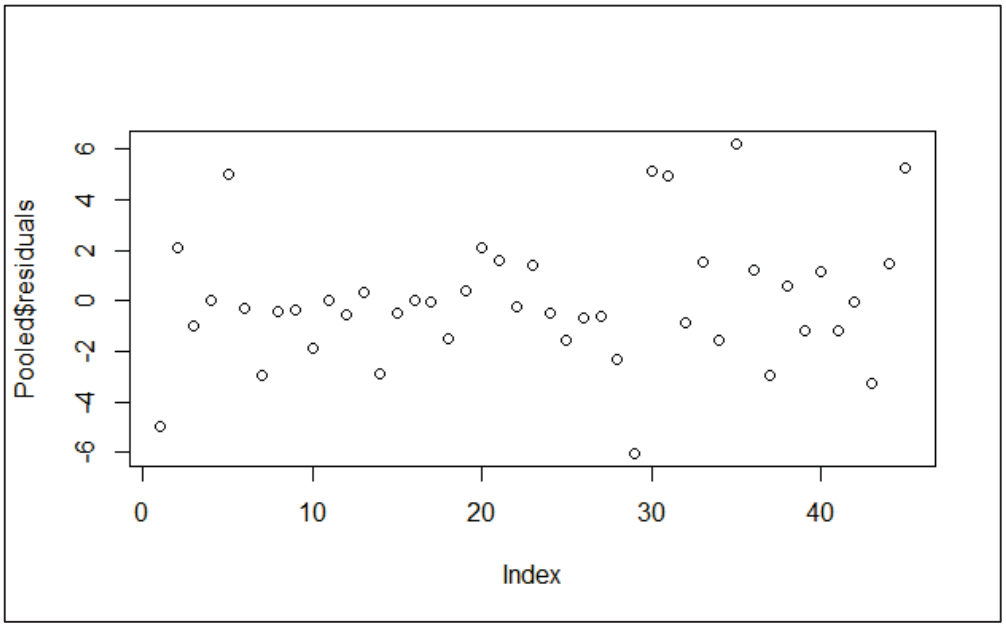


FIGURE 7 demonstrates a similar behaviour of the radical innovation variable scatter plot, with a concentration around zero, in y-axis. However, visually it is not possible to evidence any patterns.

FIGURE 8 – RESIDUALS HISTOGRAM PLOT

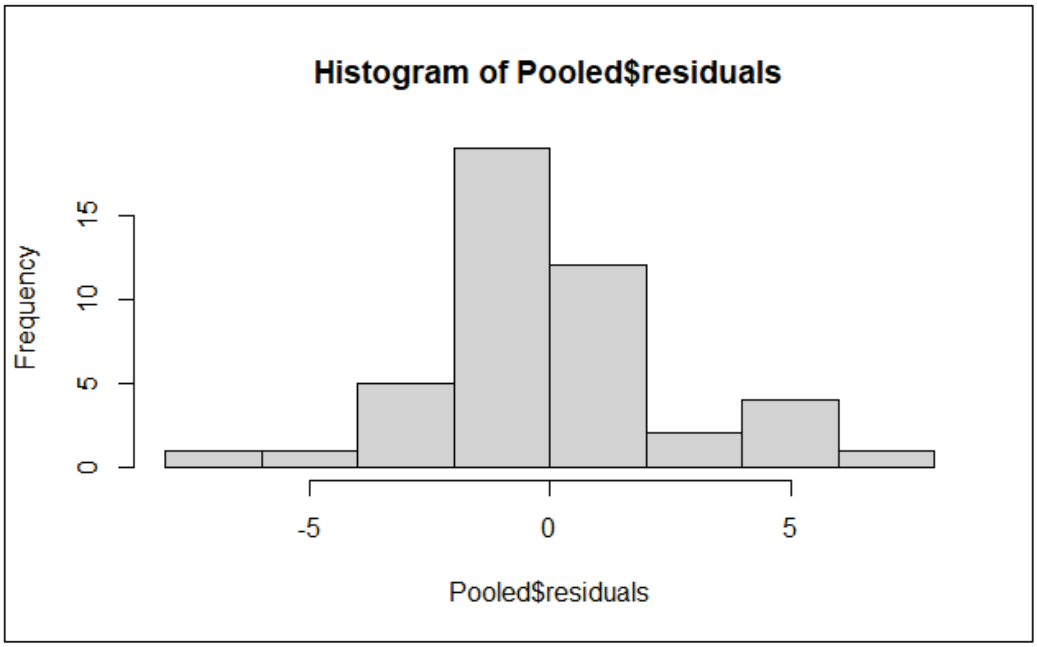


FIGURE 8 demonstrates that residuals behaviour are similar to a Gauss curve, graphically indicating that residuals have a normal behaviour, that is, error is randomly distributed. After that, it was performed the panel data analysis.

3.4.3 Panel data analysis

The panel data analysis was performed on R software and followed some steps. The first one was to run an Ordinary Least Square analysis, also called pooled regression (Colonescu, 2016; Henningsen & Henningsen, 2019). Even though OLS regression assumes a static data behaviour, this simple linear regression is compared with fixed-effects model to verify if the data are leading to a fixed effect model or it are about a random effect model (Henningsen & Henningsen, 2019).

The second step is testing the data for the fixed-effect model. Responsible to estimate within variance, the fixed-effect model indicates that individual or time-specific effects are correlated with the dependent variable (Henningsen & Henningsen, 2019). That means the variation of the dependent variable is explained by individual and/or time characteristics.

Third, with the fixed-effect model performed, it was calculated the F test, through "pFtest" function, to verify if the fixed effect is more adequate than the pooled model (Colonescu, 2016). This test was performed considering individual effects, time effects and two-ways effect, e.g. both individual and time characteristics (Henningsen & Henningsen, 2019), when p-value is below 0.05 it is considered that fixed effects are significant and better fit the data.

The fourth step was to run the random-effect model. Then, Lagrange test was performed, through "plmtest" function, which has the objective to compare the pooled model with the random-effect estimation model (Henningsen & Henningsen, 2019). Then, the Hausman test was executed to exam the difference between the estimates from the fixed-effects model and the random-effects model (Henningsen & Henningsen, 2019). Therefore, through the "phtest" function, the Hausman test was performed comparing random-effect with fixed effect considering individual, time and two-ways effects. After running Hausman test, through "phtest" function, the model that better suited to data was selected.

Fifth, with the selection of the model, it was tested heteroscedasticity through Breusch-Pagan heteroscedasticity test (Colonescu, 2016). Using "plmtest" it was possible to set Breusch-Pagan test, where p-values greater than 0.05 indicates that data does not present heteroscedasticity behaviour.

Sixth, data were tested for cross-sectional dependence. Considering that the sample is considered to have a size distortion, e.g. N is large and t is finite, Pesaran test was performed (Hoyos & Sarafidis, 2006). Hence, "pcdtest", adjusted for Pesaran CD test for cross-sectional dependence in panels, was executed. In this sense, p-values under 0.05 indicates that individuals are cross-sectionally dependent and errors are correlated with individuals (Henningsen & Henningsen, 2019), that is, individuals might have a similar source of variation, which was not predicted.

Seventh, Breusch-Godfrey test for autocorrelation, that is, general serial correlation, was run, in which the alternative hypothesis is that exist serial correlation in idiosyncratic errors (Colonescu, 2016). In this sense, p-value under 0.05 indicates that, using residuals of fixed and random-effects model, errors are related with a not predicted source of variation. To do so, "pbgtest" function was used.

Eight, Variance Inflation Factor was procedure to assess collinearity. Values up to 5 indicate no collinearity issues (Hair et al., 2014).

With no issues in previous tests, the next section discusses the hierarchical regression analysis, which was the technique applied to test hypotheses.

3.4.4 Hierarchical regression analysis

The hierarchical regression (HR) analysis technique consists of regressions calculated in a sequence, to verify the change in the coefficient of determination (R^2) and effects size. Usually HR is used to determine the predictors quality, but in this study it was used to verify if the presence of two elements significantly better explained a phenomenon (Lewis, 2007). First, a basis model was defined, and then variables were added as it follows.

The first regression model was structured to serve as basis to measure other variables contribution to the improvement of the explanation power. It considered the dependent variable, e.g. radical innovation (RAD.INNOV), explained by the control variables, e.g. the gross domestic production (GDP) and the emergent country dummy variable (Emergent), as represented by equation II. ε_{II} is the error attributed to estimation in equation II.

$$\text{RAD.INNOV} = \text{GDP} + \text{Emergent} + \varepsilon_{II} \quad \text{(II)}$$

The second regression model was built adding to the first one the market dynamics variables, which were competitive intensity (COMP.INT) and technological turbulence (TECH.TURB), showed in equation III. ε_{III} is the error attributed to estimation in equation III.

$$\text{RAD.INNOV} = \text{GDP} + \text{Emergent} + \text{COMP.INT} + \text{TECH.TURB} + \varepsilon_{III} \quad \text{(III)}$$

In the third regression model, the collaboration networks variables – named cooperation activities with clients (COOP.CLIENTS), cooperation activities with suppliers (COOP.SUPPLIER), and cooperation activities with higher education and government institutions (COOP.HIGHORGOV) – were added to the first model. ε_{IV} is the error attributed to estimation in equation IV.

$$\text{RAD.INNOV} = \text{GDP} + \text{Emergent} + \text{COOP.CLIENTS} + \text{COOP.SUPPLIER} + \text{COOP.HIGHORGOV} + \varepsilon_{IV} \quad \text{(IV)}$$

The fourth model was designed to test the complementarity hypothesis. Then it considered all the exogenous variables, that were competitive intensity (COMP.INT), technological turbulence (TECH.TURB), cooperation activities with clients (COOP.CLIENTS), cooperation activities with suppliers (COOP.SUPPLIER), cooperation activities with higher education and government institutions (COOP.HIGHORGOV), domestic production logarithm (GDP) and the emergent country dummy variable (Emergent). ε_V is the error attributed to estimation in equation V.

$$\text{RAD.INNOV} = \text{GDP} + \text{Emergent} + \text{COMP.INT} + \text{TECH.TURB} + \text{COOP.CLIENTS} + \text{COOP.SUPPLIER} + \text{COOP.HIGHORGOV} + \varepsilon V \quad \text{(V)}$$

The hierarchical regression formulas were based on the pooled model to demonstrate the procedure inclusion sequence. When other estimation model are more adequate, the proper estimators must be added to these formulas. For example, if individual fixed-effect model are more adequate, individual-effect estimator must be added in each equation from II to V (Henningsen & Henningsen, 2019).

After establishing and calculating each regression model, the values of R^2 and R^2 adjusted, and also the effect sizes with their p-values were recorded and put together to further examination (Lewis, 2007). However, the straight variation of them was not sufficient to analyze the hypothesis. To conclude hypothesis verification, it was necessary to calculate F-test, which provides the significance of the variation in R^2.

Nevertheless, as far as it is known, F-test function in R software cannot be applied in panel data models. Therefore, it is proposed a rationale to calculate F-test to permit apply hierarchical regression analysis in panel data.

$$F = \frac{(R^2_{new} - R^2_{old}) / (k_{new} - k_{old})}{(1 - R^2_{new}) / (N - k_{new})}$$

Where:

R^2_{new} is the R^2 of the model in which variables were added;

R^2_{old} is the R^2 of the model before the variables addition;

k_{new} is the predictors' number of the model in which variables were added;

k_{old} is the predictors' number of the model before the variables addition;

N is the number of observations

After F-test analysis comparing the model with the variables individually, another regression (model 5) was procedure to verify the interaction effect between market dynamics and collaboration network. Therefore, technological turbulence and competitive intensity elements coalesce into higher order indexes through main component analysis technique (Pallant, 2007), in SPSS software, and values recorded in a new variable, named "Market Dynamics". Additionally, cooperation activities with clients, suppliers, and high education and governmental institutions were coalesced through main component analysis technique to a higher order index as well, and the variable was named "Collaboration Networks". The model V, considering pooled estimation model is represented by equation VI.

$$\begin{aligned} \text{RAD. INNOV} = {} & \text{GDP} + \text{Emergent} + \text{Market Dynamics} \\ & + \text{Collaboration Networks} + \text{Market dynamics} \\ & * \text{Collaboration Networks} + \varepsilon_{IV} \end{aligned} \quad \text{(IV)}$$

Next section presents results and discussions.

4 RESULTS AND DISCUSSION

4.1.1 Descriptives analysis

Descriptives are showed in TABLE 11 to provide a broad view about data from each variable in this research.

TABLE 11 – DESCRIPTIVES

Variable	Minimum	1st quartile	Median	Mean	3rd quartile	Maximum
Emergent	0	0	0	0.2051	0	1
RAD.INNOV	-27.714	-0.993	0.399	0.506	2.250	12.047
COMP.INT	-75.801	-5.547	-1.842	-4.753	2.102	34.588
TECH.TURB	-53.300	-1.584	1.509	-0.105	4.762	23.566
COOP.SUPPLIER	-27.070	-3.353	0.035	-0.442	3.330	21.342
COOP.CLIENTS	-34.039	-6.011	-0.716	-2.173	2.522	19.401
COOP.HIGHORGOV	-35.616	-3.966	0	-1.966	1.478	10.832
GDP	-17.834	0	0	-0.191	0.052	3.283

RAD.INNOV: Radical innovation; COMP.INT: Competitive intensity; TECH.TURB: Technological turbulence; COOP.SUPPLIER: Cooperation activities with suppliers; COOP.CLIENTS: Cooperation activities with clients; COOP.HIGHORGOV: Cooperation activities with higher education and government institutions; GDP: Gross domestic product.

The “Emergent” mean of 0.2051 indicate that the minority of countries in the sample are emergent. This is because OECD reports usually focus on countries that are OECD members, which are mostly developed ones (OECD, 2022). The 1st and 3rd quartiles, together with the median, separates the sample in four equal parts and are used to evaluate the data dispersion in each variable. The values of zero in these 3 descriptive indexes proof that there is a high concentration of the sample pertaining to the non-emergent group of countries.

The variable, with the largest amplitude was competitive intensity (min: -75.801, max: 34.588). Competitive intensity was operationalized as the difference of the percentage of firms that affirmed that introduced new product or process ongoing or abandoned innovation or organizational or marketing innovation between years (OECD & Eurostat, 2005), this largest amplitude indicates a high variation in the percentage of firms that implemented innovation., that is, high competitive intensity. The second variable with the largest amplitude was technological turbulence (min: -53.3, max: 23.5659). The technological turbulence operational definition is the difference of the percentage of firms that affirmed that introduced new product or process (technological innovation) between years (OECD & Eurostat, 2005). That means that there was a great variation in firms that affirmed they implemented process and product innovation, configuring a high technological turbulence. Therefore, the variables that are

related to market dynamics presented the most variation in the sample, presenting a higher turbulence if their amplitude is compared to the other variables amplitude in this study.

Regarding the indicators composing the collaboration networks concept, the cooperation activities with clients presented the largest amplitude, e.g. is the type of linkage that present the most variation in the sample. The collaboration activities with high education and government institutions were the collaboration networks element that varied the least in the sample.

Next, panel data analysis result is presented.

4.1.2 Panel data analysis results

Following steps panel data analysis procedures described in methodology section (Item 3.4.3), the Panel data analysis' first step was to procedure a pooled model estimation, that is, the ordinary least square estimation regression model . The second one was to procedure a fixed-effect model estimation. Results from the estimation models are present in TABLE 12.

TABLE 12 – PANEL DATA MODELS' RESULTS

	Pooled model	Fixed-effect model	Random-effect model
Intercept	0.159 (0.759)	-	0.159 (0.758)
COMP.INT	-0.072 (0.464)	-0.168 (0.504)	-0.072 (0.460)
TECH.TURB	0.352 (0.002)**	0.332 (0.295)	0.352 (0.001)**
COOP.CLIENTS	0.130 (0.068)	0.177 (0.092)	0.130 (0.061)*
COOP.SUPPLIER	-0.008 (0.890)	-0.077 (0.537)	-0.008 (0.889)
COOP.HIGHORGOV	-0.052 (0.630)	-0.094 (0.535)	-0.052 (0.627)
Control variables			
GDP	0.184 (0.538)	0.232 (0.675)	0.184 (0.535)
Emergent	-0.274 (0.823)	-	-0.274 (0.822)
Indexes			
R^2	0.563	0.606	0.563
Adjusted R^2	0.489	-0.260	0.489
F-statistic	7.561	3.847	-
χ^2	-	-	52.929
p-value	0.000	0.016	0.000

RAD.INNOV: Radical innovation; COMP.INT: Competitive intensity; TECH.TURB: Technological turbulence; COOP.SUPPLIER: Cooperation activities with suppliers; COOP.CLIENTS: Cooperation activities with clients; COOP.HIGHORGOV: Cooperation activities with higher education and government institutions; GDP: Gross domestic product.
**: p-value < 0.01; *: p-value < 0.05.

Previous the comparison between estimation models, the negative adjusted coefficient of determination (Adjusted R^2) from fixed-effect model, while R^2 is positive, already signals that fixed-effect model might not be adequate to data distribution.

After running the models with pooled and fixed-effect estimation procedures, "pFtest" function (F test) was performed to verify if the fixed effect is more adequate than the pooled

model (Colonescu, 2016). Then, when testing the fixed effect versus the pooled model considering individual effects, the p-value (0.842) support the null hypothesis of individual characteristics not influencing the data. This result indicates that individual effects are not correlated with the relationships tested. It means that country differences in the sample did not influence the differences in radical innovation explained by market dynamics and collaboration networks. This result is different from the ones presented in sample characterization section (Item 3.3.2). The sample characterization section demonstrated different behaviour of variables when individuals were country-mean grouped by continent. Even though there is difference in the variables behaviour between continents, the result from F test showed that different countries do not significantly influence on how variables relates to each other.

Moreover, when testing the fixed effect versus the pooled model considering time effects, the p-value (0.308) supported the null hypothesis of time characteristics not influencing the data. This result indicates that time effects are not correlated with the relationships tested. It means that the waves differences, each wave corresponding to time periods, in the sample did not influence the differences in radical innovation explained by market dynamics and collaboration networks. Therefore, the effects of the independent variables (competitive intensity, technological turbulence, cooperation with clients, suppliers and high education and government institutions, and the control variables) on the dependent variable (radical innovation) is constant over time.

Finally, when testing the fixed effect versus the pooled model considering two-ways effects, the p-value (0.849) supported the null hypothesis of both individual and time characteristics not influencing the data. This result indicates that individual and time effects together are not correlated with the relationships tested. It means that the countries differences together with waves differences in the sample did not influence the differences in radical innovation explained by market dynamics and collaboration networks. Moreover, the market dynamics and collaboration networks effects on radical innovation are constant in time and do depend on whether the country is emergent or not. The TABLE 13 summarizes the F test results.

TABLE 13 – PFTEST SUMMARY

Fixed-effects cathegory	**Description**	**p-value**	**Result**
Individual effects	Pooled model versus Fixed individual effects	0.842	Individual effects are not correlated with the relationships tested.
Time effects	Pooled model versus Fixed time effects	0.308	Time effects are not correlated with the relationships tested.
Two-ways effects	Pooled model versus Fixed individual and time effects	0.849	Individual and time effects together are not correlated with the relationships tested.

After analysing pFtest, it is concluded that fixed effects, in comparison with the pooled model, is not the appropriate estimation model to the sample in this research. Then, the fourth step was to calculate the random-effect model estimation, which is recorded in TABLE 12 (p. 41). Afterwards, Lagrange test was executed through "plmtest". Lagrange test was calculated comparing the random-effect model with pooled model (p-value = 0.055). The results indicated that the random-effects model was the one that is the most adherent to the dataset (p-value < 0.10). Then the Hausman test was executed, through the "phtest function, to compare the random and the fixed-effects models (TABLE 14).

Regarding the comparison between random-effects and individual-fixed-effects model, Hausman test, indicate that random-effects is the most adequate to represent the data set (p-value > 0.01). When the random-effects model is compared with time-fixed-effects, the random-effects is the most appropriate estimation model signed by Hausman test (p-value > 0.10). Then, when the Hausman test compared the random-effects model with the two-ways-fixed-effects model, the fixed-effects is considered a better estimation model than random-effects model (p-value < 0.10). However, the negative adjusted R^2 reveals that fixed-effects is not an appropriate estimation model for the data analysed.

TABLE 14 – HAUSMAN TEST SUMMARY

Fixed-effects category	**Description**	**p-value**	**Result**
Individual effects	Random-effect model versus Fixed individual effects	0.473	Random-effects model is better representative of the dataset
Time effects	Random-effect model versus Fixed time effects	0.994	Random-effects is better representative of the dataset
Two-ways effects	Random-effect model versus Fixed individual and time effects	0.000	Two-ways fixed-effects model is better representative of the dataset

Considering the tests calculated so far, that is, i) F test, which compared the pooled and the fixed-effects models, ii) the Lagrange test, comparing the pooled and random-effects models, and iii) the Hausman test, which compares the fixed-effects and random-effects model, random effects better represent the dataset. However, the variance between coefficients and their significance test is almost null, with Lagrange test result so close to the edge of 0.05 (p-value = 0.055). This similarity might be explained by the data characteristic of being considered a short panel, i.e. the number of individuals larger than the number of periods analysed. Calling Occam's razor principle, which states that "the simpler explanation is usually the best", the pooled model is considered the most adequate. Therefore, the next analysis are performed over the pooled model.

The fifth step was to assess for heteroscedasticity through Breush-pegan heteroscedasticity test (Colonescu, 2016). With the p-value over then 0.05 (p-value = 0.569) the issues regarding heteroscedasticity were eliminated. It was expected since proxies fundament on lagged-difference treatment, known to be a manner to deal with time-based heteroscedasticity, common to longitudinal and panel data (Colonescu, 2016; Henningsen & Henningsen, 2019).

The sixth procedure was cross-sectional dependence assessment. To evaluate cross-sectional dependence, the Pesaran test was executed (Hoyos & Sarafidis, 2006), through "pcdtest" function. The test result (p-value = 0.329) indicates the data were not cross-sectional dependent (p-value > 0.05), eliminating correlation between the error terms with individuals.

Then, the seventh step was to procedure Breusch-Godfrey test for autocorrelation (Colonescu, 2016). The results (p-value = 0.442) demonstrate there are no issues with autocorrelation (p-value < 0.05). This means the error terms do not correlate with the variables. With no issues regarding heteroscedasticity, cross-sectional dependence or autocorrelation, the pooled estimated model was submitted to hierarchical regression analysis.

Finally, Variance Inflation Factor (VIF) test was procedure to assess variables collinearity (Hair et al., 2014). Results are presented in TABLE 15 and indicate no collinearity issues (VIF < 5).

TABLE 15 – VARIANCE INFLATION FACTOR RESULTS

Variable	Variance Inflation Factor (VIF)
Competitive intensity	4.279
Technological turbulence	4.609
Cooperation activities with clients	2.173
Cooperation activities with suppliers	1.332
Cooperation activities with higher education and government institutions	2.155
Gross Domestic Product	1.196
Emergent	1.043

Next, the hierarchical regression analysis was performed.

4.1.3 Hierarchical regression analysis results

The hierarchical regression (HR) analysis consisted on to calculate regressions in sequence to verify the differences about the coefficient of determination (R^2) and effects size (Lewis, 2007). Therefore, after the selection of the estimation model in the previous section

(random-effects model) it was specified four models to be compared with themselves and to support the hypothesis testing.

The first model consists of regressing the control variables, e.g. Gross Domestic Product (GDP) logarithm and the emergent country dummy variable, to the dependent variable, e.g. radical innovation. The second model consists of adding to the first model the market dynamics variables, e.g. competitive intensity and technological turbulence. The third model adds collaboration network, e.g. cooperation activities with clients, with suppliers and with high education and government institution, to the first model. The fourth and last model consist of integrating all variables mentioned in the previous models.

TABLE 16 presents the results from hierarchical regression, and the F test results to assess the significance of the differences in R^2. Each column represents one model, labeled in the first line. The values computed in the variables line correspond to the effect sizes and the values in parentheses are the p-values to the corresponding effect size. In the table section named as "F results", the values recorded represent the F calculated after the formula VI indicated in the item 3.4.4 (p. 57), and the value in parenthesis are the p-values calculated after the F test results to assess significance to the difference in R^2.

F test was performed to compare the models 1 and 2, models 1 and 3, and models 2 and 4. Model 1 and model 4 were not compared because models 2 and 3 revealed significant improvement in R^2 in comparison with the model 1. The model 2 was not compared to the model 3 because it was not adherent to the hypotheses testing. The model 4 was compared to model 2 and not model 3 because the model 2 had the greatest R^2 value.

TABLE 16 – HIERARCHICAL REGRESSION RESULTS

	Model 1	Model 2	Model 3	Model 4
Intercept	1.362 (0.013)*	0.196 (0.655)	1.220 (0.015)*	0.159 (0.759)
COMP.INT	-	-0.035 (0.573)	-	-0.072 (0.464)
TECH.TURB	-	0.355 (0.000)**	-	0.352 (0.002)**
COOP.CLIENTS	-	-	0.272 (0.000)**	0.130 (0.068)
COOP.SUPPLIER	-	-	-0.049 (0.450)	-0.008 (0.890)
COOP.HIGHORGOV	-	-	-0.144 (0.212)	-0.052 (0.630)
Control variables				
GDP	-0.309 (0.096)	0.113 (0.715)	0.759 (0.020)*	0.184 (0.538)
Emergent	-1.011 (0.476)	0.215 (0.859)	-0.719 (0.570)	-0274 (0.822)
Indexes				
R^2	0.058	0.447	0.331	0.563
Adjusted R^2	0.023	0.401	0.257	0.488
p-value	0.200	0.000**	0.002**	0.000***
F-statistic	1.656	9.709	4.460	7.561
F results				
Model 1	-	-	-	-
Model 2	53.544 (0.000)**	-	-	-

Model 3	20.590 (0.000)**	-	-	-
Model 4	-	13.230 (0.000)***	-	-

RAD.INNOV: Radical innovation; COMP.INT: Competitive intensity; TECH.TURB: Technological turbulence; COOP.SUPPLIER: Cooperation activities with suppliers; COOP.CLIENTS: Cooperation activities with clients; COOP.HIGHORGOV: Cooperation activities with higher education and government institutions; GDP: Gross domestic product logarithm.
**: p-value < 0.01; * p-value < 0.05.

The p-values in the TABLE 16 from each model indicates that, with exception of model 1, all other 3 models are significant. It means that the models 2, 3 and 4 are valid and explain more than 30% of the dependent variable, e.g. radical innovation. The non-significance of the model 1 indicates that control variables, such as GDP and being emergent or not, are not enough to explain the differences in countries radical innovation. This result question the Evolutionary Theory of Innovation (ETI) ((Nelson & Winter, 1977; Schumpeter, 1997) argument that economic cycles are related to innovation. The ETI defends a direct iteration relationship between the market and innovation, with innovation being a cornerstone on economic wealth (Meirelles, 2009; Schumpeter, 1997).

However, the regression results indicate that the control variables had no significant effect on influencing radical innovation. The only exception was GDP in model 3, which corresponds the inclusion of collaboration networks and control variables influencing radical innovation (effect size = 0.759, p-value = 0.020). This specific regression indicates that GDP differences positively influences the influence the relationship between collaboration networks and radical innovation. This result follows previous literature finding arguing economic landscape influences firms decisions regarding innovation (Sarwar et al., 2021).

The non-significance of the emergent variable and GDP in the other models might be due to the size difference between groups (emergent vs. non-emergent) or the GDP missing values. However, the missing values were not considered problematic. In respect to the sample and this study approach considering GDP and the economic countries classification as emergent or not, these economic elements did not present direct relationship with innovation. Then, considering this research's sample and variables, other elements closer to the level of the firm are more relevant to explain the radical innovation variation (Möller et al., 2020).

TABLE 17 presents the model 5 results. Model 5 complements the hierarchical regression procedures in order to test the interaction between market dynamics and collaboration networks.

TABLE 17 – MODEL 5 RESULTS

	Model 5
Intercept	0.340
Market Dynamics	3.221 (0.000)**
Collaboration Networks	-0.147 (0.773)
Market Dynamics * Collaboration Networks	2.457 (0.004)**
Control variables	
GDP	0.025 (0.931)
Emergent	-0.188 (0.871)
Indexes	
R^2	0.579
Adjusted R^2	0.530
p-value	0.000**
F-statistic	11.842

GDP: Gross domestic product logarithm.
**: p-value < 0.01; * p-value < 0.05.

In Model 5 (TABLE 17), which has the aim to represent the interaction between market dynamics and collaboration networks, the p-value significance (p-value < 0.05) indicates this model is significant and explain more than 57%. The control variables were not significant following the other models behaviour.

Market dynamics presented positive and significant (effect size = 3.221, p-value = 0.000) influence in radical innovation co-directional with models 2 and 4. Collaboration networks effect was not significant (p-value > 0.05). The interaction effect was significant (size effect = 2.457, p-value = 0.004). Those results confirms previous literature finding of different market elements influencing innovation differently and that these elements interact within each other (Flaig et al., 2021b; Hughes & Chandy, 2021; Möller et al., 2020; Ojha et al., 2020). However, when collaboration networks elements coalesce to compose a single variable, and together with market dynamics variable, they present no significant effect, contrary to what is described in literature (Baker & Nenonen, 2020; Möller et al., 2020).

Next, the results are discussed in terms of hypotheses achievement.

4.1.4 Market dynamics relationship with radical innovation

The first hypothesis stated that market dynamics positively relates to radical innovation. Model 2 in TABLE 16 indicates that the market dynamics elements can explain 42.5% of radical innovation. Analysing the F test comparing model 1 and 2 (F = 53.544, p-value = 0.000), the market dynamics antecedents inclusion significantly improves the R^2. That means they are relevant predecessors to radical innovation. Being relevant to explain radical innovation, market dynamics are considered favouring elements to radical innovation.

Regarding each element of marketing dynamics, competitive intensity, when combined with technological turbulence, did not present influence in radical innovation (p-value > 0.05), but technological turbulence, when combined with competitive intensity, presents a significant 0.355 effect in radical innovation. This means that for each unit of positive variation in technological turbulence, radical innovation might be positively vary in 0.355 unit. This results confirms H1, when market dynamic element positively influences radical innovation.

Considering the theoretical background, the argument of increase in technological turbulence augmenting the volume of radical innovation is confirmed. This results is in line with previous evidences, which argues that the more the market changes, e.g. in form of technological turbulence, the more firms will be motivated to introduce innovations to maintain its competitive advantage, that is, what guarantee their survival and/or overcome their competitors (Hughes & Chandy, 2021). It also confirms that, considering technological turbulence a market aspect, the environment triggers organizations decisions capable to change the market dynamics (Flaig et al., 2021b; Nenonen et al., 2019; Schumpeter, 1997), e.g. implementing radical innovation (Flaig et al., 2021b). Even though market-shaping research, one of the theoretical approaches used in this thesis, focus on the firms' decisions and strategies to manage market changes, the aspects of firm perception and sensing about the market dynamics triggers the proactive firms' action towards to shape the market (Kleinaltenkamp et al., 2022; Möller et al., 2020; Nenonen et al., 2019). Therefore, the technological turbulence influence on radical innovation infer that the volume of firms launching new products or processes – which might be new to the market or just new to the firm – might trigger firms to develop and implement new products and processes that are new to the market.

In respect to competitive intensity, this result was not as expected. Market shaping literature argues that the concurrence of strategies from different market shapers, e.g. firms that want to shape the market, from introducing a radical innovation to acquiring market actors, might favour other firms to take decisions in order to embrace the changes or interrupt them (Flaig et al., 2021a; Nenonen et al., 2019; Vargo et al., 2023). Regarding the non-significant effect, previous study evidenced a counterintuitive result about the competitive intensity influence in innovation. In this case, it was found a competitive intensity negative effect on innovation by the presence of technological turbulence – defined as the extent to which technology changes and create new market opportunities – and market turbulence – defined as changes in customer needs and desires (Ojha et al., 2020). When tested individually, competitive intensity significantly and positively influence innovation. The explanation was a

cannibalization effect capable to change the signal of the effect, because market turbulence effect was so strong that made technological turbulence effect non-significant and competitive intensity to behaviour as a negative effect (Ojha et al., 2020).

Therefore, a regression was calculated with the control variables and competitive intensity as predecessors, to verify if this variable alone can cause some effect on radical innovation (called model 2.1). Results are present in TABLE 18.

TABLE 18 – ADDITIONAL REGRESSION IN MARKET DYNAMICS INVESTIGATION

	Model 2.1
Intercept	1.020 (0.032)*
COMP.INT	0.158 (0.003)**
Control variables	
GDP	0.370 (0283)
Emergent	0.067 (0.957)
Indexes	
R^2	0.210
Adjusted R^2	0.164
p-value	0.006**
F-statistic	4.607

COMP.INT: Competitive intensity; GDP: Gross domestic product logarithm.
**: p-value < 0.01; * p-value < 0.05.

The result demonstrates that competitive intensity, without the presence of technological turbulence, has a positive (effect size = 0.158) and significant (p-value = 0.006) relationship with radical innovation. The effect of competitive intensity alone being significant, a variance inflation factor (VIF) test was procedure with model 2 to assess collinearity between competitive intensity and technological turbulence. VIF values depart collinearity issues between these elements (competitive intensity VIF = 2.071, technological turbulence VIF = 2.220). Then, the Hausman test was performed to assess endogeneity between competitive intensity and technological turbulence. To undertake that, technological turbulence, GDP and emergent variables were regressed to competitive intensity. This regression's residuals were added to another regression, were technological turbulence was explained by GDP and emergent variables. Residuals from competitive intensity did not explain technological turbulence (p-value > 0.05), departing endogeneity issues.

This result is in line with previous finding, were other elements, i.e. market turbulence and technological turbulence, changed the variable effect size and behaviour (Ojha et al., 2020). In the case of this study, technological turbulence have such a strong effect on radical innovation that suppress the influence of competitive intensity effect.

4.1.5 Collaboration networks relationship with radical innovation

The second hypothesis states that collaboration networks positively relate with radical innovation. Model 3 in TABLE 16 indicates that collaboration networks elements can explain 33,1% of radical innovation. The F test comparing model 1 and model 3 (F = 20.590; p-value = 0.00) indicates a significant improvement in R^2 because of collaboration networks predecessors' inclusion. Therefore, collaboration networks elements are relevant to explain radical innovation.

Further analysing each element effect size, cooperation activities with clients had a positive and significant effect on radical innovation (effect size = 0.272; p-value = 0.00). However, cooperation activities with supplier did not present significant effect on radical innovation (p-value > 0.05) and cooperation activities with higher education and government institutions also did not presented a significant effect on radical innovation (effect p-value > 0.05).

The positive and significant effect of cooperation activities with clients on radical innovation (effect size = 0.272; p-value = 0.00) confirms literature arguments that once innovation success is related to its usage (OECD & Eurostat, 2018), clients are a relevant stakeholder to connect with, when developing innovation. Through establishing cooperation activities with clients, firms are able to collect information about their needs and desires, increasing the probability of innovation to meet clients' needs and desires to achieve success, that is, being accepted by the customer market (Efrat et al., 2017). Then, this research result demonstrates that, in order to increase the probability of radical innovation success, firms mobilize their networks towards their clients.

An unexpected result from this research was the no effect of cooperation activities with suppliers on radical innovation (p-value > 0.05). To verify if occurred a suppression from other variables effect, a regression was calculated with the control variables and cooperation activities with suppliers as predictors from radical innovation, called model 3.1. Results from this additional regression are present in TABLE 19.

TABLE 19 – ADDITIONAL REGRESSION IN COLLABORATION NETWORKS INVESTIGATION I

	Model 3.1
Intercept	1.173 (0.025)
COOP.SUPPLIER	-0.016 (0.802)
Control variables	
GDP	0.663 (0.072)
Emergent	-0.196 (0.892)
Indexes	

R^2	0.070
Adjusted R^2	0.015
p-value	0.293
F-statistic	1.275

COOP.SUPPLIER: Cooperation activities with suppliers; GDP: Gross domestic product logarithm.
**: p-value < 0.01; *: p-value < 0.05.

TABLE 19 demonstrates that, alone, cooperation activities with suppliers did not present a significant relationship with radical innovation. This result contrasts with the literature that cooperation activities with suppliers could foster radical innovation (Antràs, 2020; Genc et al., 2019). The argument to propose such relationship is because suppliers are in charge of providing inputs to organization, and choosing the right ones might introduce new technology of materials, components and systems (Yu et al., 2014), being fruitful to innovation. Despite, establishing a partnership with suppliers, due to the different nature of suppliers and forms they might bust innovation, is complex and this complexity might have blurred results. Unfortunately, the data available does not permit to investigate further these nuances, being an investigation opportunity for future research, through other databases or methods.

The cooperation activities with higher education and government institutions did not influence significantly radical innovation (p-value > 0.05). This result was the opposite of evidences found in spin-off literature, which is focused on cooperation between higher education with firms (Mira-Solves et al., 2021; Walter et al., 2006), and literature about enterprise-government partnerships to favour innovation studies (Munksgaard & Medlin, 2014; Roper & Turner, 2020). Another additional regression was calculated with the control variables and the cooperation activities with higher education and government institutions to verify if the relationship with radical innovation is different from the one in model 3 (TABLE 16, p. 65). Results from model 3.2 are in TABLE 20.

TABLE 20 – ADDITIONAL REGRESSION IN COLLABORATION NETWORKS INVESTIGATION II

	Model 3.2
Intercept	1.083 (0.045)*
COOP. HIGHORGOV	0.059 (0.542)
Control variables	
GDP	0.718 (0.050)
Emergent	-0.119 (0.934)
Indexes	
R^2	0.083
Adjusted R^2	0.026
p-value	0.240
F-statistics	1.449

COOP.HIGHORGOV: Cooperation activities with higher education and government institutions; GDP: Gross domestic product logarithm.
**: p-value < 0.01; *: p-value < 0.05.

TABLE 20 demonstrates that alone, the cooperation activities with higher education and government institutions does not present effect on radical innovation, when regressed alone (p-value > 0.05), which is the same result presented on model 4, in TABLE 16..

Therefore, hypothesis 2 is confirmed, because the element cooperation activities with clients element, from collaboration networks, positively and significantly effects radical innovation

4.1.6 The complementarity between market dynamics and collaboration networks relationship with radical innovation

The third hypothesis states that the complementarity between market dynamics and collaboration networks positively relates with radical innovation. The complementarity effect was assessed by the increase in R^2 of two models, and F was calculated to verify if the R^2 was significant, as described in item 3.4.4 (p.57).

Then, the complementarity was analysed trough the comparison between the model 2 and the model 4, together with model 5. Model 2 was selected because it presented the highest R^2 in comparison with models 1 and 3. Analysing the R^2 differences, model 4 indicates the highest one, indicating that market dynamics and collaboration networks elements together can significantly (p-value = 0.00) explain 56.3% of radical innovation. The value of F, comparing the models 2 and 4 (F = 13.230; p-value = 0.00) indicates that the combination of market dynamics and collaboration networks significantly improves R^2 from 0.447 to 0.563. The 16% significant difference proves the conjoint effect of the elements from market dynamics and collaboration networks.

Additionally, the model 5 (TABLE 17, p. 67), indicates that the interaction between market dynamics and collaboration networks positively and significantly (effect size = 2.457, p-value = 0.004) influences radical innovation. The interaction (model 5) and the conjoint effect (model 4) results leads to the confirmation of hypothesis 3.

The confirmation of the third hypothesis reinforces the theoretical argument of markets being complex systems that interact and influence firms decisions (Möller et al., 2020; Schumpeter, 1997), e.g. to decide to innovate (Nenonen & Storbacka, 2018; Stathakopoulos et al., 2022).

Deepening the analysis to the effect sizes of the predecessor elements that present significant relationship with radical innovation (p-value < 0.05) regarding model 4, the technological turbulence's effect size of 0.352 was the highest one, followed by cooperation

activities with clients, which present an effect size of 0.130. Previous study argued that collaboration and market dynamic elements might relate with innovation as antecedents (D. Kafetzopoulos & Skalkos, 2019; Peters et al., 2020). Therefore, considering technological turbulence pertaining to a macro level and cooperation activities with clients to innovation as a meso level from markets, this study provided evidence of an interaction between two market levels (Windahl et al., 2020), in the form of complementarity.

Literature already argued that markets are multi-layered, nested and each layer interacts within each other, and this interaction influences firms decisions (El-Ansary et al., 2018; Möller et al., 2020; Shaw, 2020). However, literature lacks providing evidences about these interactions. These interactions were approached by exploring the complementary role of market dynamic and collaboration effects to favour radical innovation by analysing the conjoint and interaction effect. Results confirm market elements differently influence radical innovation. Additionally, technological turbulence, competitive intensity and cooperation activities with clients together explain more radical innovation than each element studied itself. Finally, the interaction between market dynamics and collaboration networks is confirmed, indicating that the complementary effect occurs by the conjoint effect and interaction between market dynamics and collaboration networks.

5 CONCLUSION

This study relied on quantitative secondary panel data from OECD and aimed to explore the complementarity of market dynamics and collaboration networks to favour radical innovation. This general objective was pursued by integrating Evolutionary Theory of Innovation and Market-shaping approach. The findings demonstrate a synergistic potential of market dynamics and collaboration networks as dual enablers of radical innovation, offering both theoretical enrichment and practical implication. To achieve the general objective, three other specific objectives were stated.

The first objective was to verify the influence of market dynamics on radical innovation. The results from the first hypothesis allowed achieving this objective. The results showed that market dynamics positively influence radical innovation. Specifically, the market dynamics element that had significant positive effect was the technological turbulence, confirming hypothesis 1, consequently achieving the first specific objective.

The second objective was to verify the influence of collaboration networks on radical innovation. The results showed that cooperation activities with clients to innovation positively influences radical innovation confirming hypothesis 2. Then, the second specific objective was achieved.

Lastly, the third objective was to assess the market dynamics and collaboration networks complementarity to favour innovation. Results presented a significant complementarity between market dynamics and collaboration networks through conjoint and interaction effects, confirming hypothesis 3. Therefore, the third specific objective was also achieved.

The achievement of the research objectives underscored the synergistic potential of market dynamics and collaboration networks as dual enables of radical innovation, offering both theoretical and practical contribution, which are described in the next section.

5.1 THEORETICAL CONTRIBUTIONS

The first theoretical contribution originates in the results from seeking the first hypothesis that stated that market dynamics positively influence radical innovation. The results showed that both aspects of market dynamics, i.e. competitive intensity and technological turbulence, positively influence radical innovation, aligning with previous literature findings (Hughes & Chandy, 2021; Ojha et al., 2020). However, when analysed together, just the

technological turbulence had a significant impact. Therefore, this research sheds light to the need for exploring different market dynamics aspects together to investigate nuances of its impact on favouring radical innovation (Ojha et al., 2020). In this case, the results indicated that, in the sample, the technological turbulence aspect had a strong effect on radical innovation that suppress the influence of competitive intensity effect. Assuming markets as complex systems, which are nested (Möller et al., 2020; Nelson & Winter, 1977; Schumpeter, 1997; Shaw, 2020; Zhang & Watson IV, 2020), it was expected that elements composing these markets would interact. However, it was expected that both, competitive intensity and technological turbulence would positively influence radical innovation (Hughes & Chandy, 2021; Tang et al., 2021; Yu et al., 2014). This counterintuitive finding might be due to a cannibalization effect of technological turbulence on the variation of competitive intensity influence on radical innovation (Ojha et al., 2020).

The second theoretical contribution relates to the second hypothesis confirmation, which stated that collaboration networks positively relate with radical innovation. The results presented different impact of cooperation activities considering the stakeholders linkages. Further analysing the volume of firms linking to clients, to suppliers and high education and government institutions provided a distinct perspective. At once, this approach allowed at the same time: i) a detailed view of the firm's linkages when compared to studies focused on network capability that studied the organization's ability to manage networks (Costa & Didonet, 2020; Farida & Nuryakin, 2021; Parida et al., 2017); and ii) a broader view of collaboration networks considering different stakeholders when compared to the large amount of studies focusing on the relationship with each stakeholder (Antràs, 2020; Efrat et al., 2017; Genc et al., 2019; D. Kafetzopoulos & Skalkos, 2019; Mira-Solves et al., 2021; Munksgaard & Medlin, 2014; Reddy et al., 2020; Roper & Turner, 2020; Saridakis et al., 2019; Walter et al., 2006; Yu et al., 2014). This approach permits the literature to have evidences that, despite the contribution to each stakeholder to radical innovation, each one presents a different behaviour in the network as a whole (Gulati et al., 2000)

The third theoretical contribution is also related to the second hypothesis. During the tests, it was verified that each linkage contributed differently to favour radical innovation, and cooperation activities with clients are the linkages that maintained significant impact adding the market dynamics variables. The relationship of higher education and government institutions with radical innovation changed in the presence of other variables. Isolated it had no significant effect, together with cooperation activities with clients and suppliers it had negative significant impact and in the presence of market dynamics variables the effect was not

significant. This result reinforce that even though literature argues that every linkage is relevant to innovation development (Antràs, 2020; Efrat et al., 2017; Genc et al., 2019; D. Kafetzopoulos & Skalkos, 2019; Mira-Solves et al., 2021; Munksgaard & Medlin, 2014; Reddy et al., 2020; Roper & Turner, 2020; Saridakis et al., 2019; Walter et al., 2006; Yu et al., 2014), they contribute differently to radical innovation and must be analysed in the network context, that is, conjointly. This is due to the complexity and nested market characteristics, where market players are direct or indirectly linked to each other (Möller et al., 2020; Nelson & Winter, 1977; Schumpeter, 1997; Shaw, 2020; Zhang & Watson IV, 2020). Therefore, approaching the linkages a firm conjointly develops broadens the analysis to the firm's whole network, and highlights the global contribution each linkages have on a dependent variable, i.e. each stakeholder's contribution to radical innovation.

The fourth theoretical contribution relates to the third hypothesis, which stated that the complementarity between market dynamics and collaboration networks positively relates with radical innovation. The confirmation of this hypothesis provides empirical evidences of the relationship of two diverse market levels to favour innovation (Baker & Nenonen, 2020; Layton, 2015; Möller et al., 2020; Shaw, 2020), outstanding previous literature evidences that focused just on one level. This conjointly effect is particularly important to incorporate market-shaping and Evolutionary Theory of Innovation view of the market. Considering markets as complex systems, which are nested and multilayered (Möller et al., 2020; Nelson & Winter, 1977; Schumpeter, 1997; Shaw, 2020; Zhang & Watson IV, 2020), it is more adherent to reality that studies consider the elements conjointly, i.e. collaboration networks as a meso-level element and market dynamics as a macro-level element, contributing to the results external validity (Malhotra, 2010).

5.2 MANAGERIAL CONTRIBUTIONS

This research offers some contributions for firms aiming to achieve radical innovation.

The first contribution is related to market dynamics. Instead of facing competition intensity and technological turbulence as threats and a challenge (Chandy & Tellis, 1998; Hughes & Chandy, 2021; Rousseau et al., 2016; Tang et al., 2021; Yu et al., 2014), results demonstrate that they can serve as opportunities. Competitive intensity and technological turbulence act as innovation catalysts, but the last one plays a pivotal role in favouring innovation.

The second contribution to managers is about collaboration networks favouring radical innovation. In this sense, firms must look into each type of linkages, e.g. cooperation with clients, suppliers, high education and government institutions, to strategically design and manage networks (A. F. Maciel & Fischer, 2020; Möller et al., 2020). Additionally, firm's cooperation activities should be managed in a holistic manner, because one type of relationship might influence others.

Third, managers can benefit from a deeper understanding on how market dynamics and collaboration networks work in tandem (Möller et al., 2020). Results demonstrates that there is a complementary effect in market elements pertaining to different levels, i.e. market dynamics, in a macro level, and collaboration networks, in a meso-level. This alignment allows firms to respond to and anticipate environmental changes more effectively, improving innovation outcomes and fostering long-term competitiveness.

5.3 RESEARCH LIMITATION AND FUTURE STUDIES

While this research offers contributions, it is not without limitations. Regarding the theoretical approaches considered to explore the complementarity of market dynamics and collaboration networks to favour radical innovation, this research based its arguments on Evolutionary Theory of Innovation (Nelson & Winter, 1977; Schumpeter, 1997) and market-shaping approach (Jaworski et al., 2020; Nenonen & Storbacka, 2018). Together they permitted balance different levels of the market and examine their complementary effect on favouring radical innovation. However, other theoretical lenses might have provided different insights to the theme. For example, agency theory can offer a different perspective to how collaboration networks influence innovation, since the collaboration networks could be investigated under the governance systems implied in relationship built within the stakeholders and how they might be influenced by the market dynamics and impact radical innovation (Eisenhardt, 2015; Jensen & Meckling, 2008).

This research only considers radical innovation. If incremental innovation was considered, maybe the results could present different insights. This is because incremental innovation are different from radical ones, and can be more susceptible by competitors, because they require less resources to be developed (OECD & Eurostat, 2005).

The market dynamics variables tried to include the most elements as possible, according to the concepts and data availability. Therefore, other market dynamics elements could be considered in future studies, such as clients change of needs and desires (Kindström

et al., 2018; Ojha et al., 2020; Turulja & Bajgoric, 2019), politics setting, economics environment, and so forth (Kjellberg et al., 2015; Kjellberg & Murto, 2021).

This study advance collaboration networks studies comprising different types of linkages in the same study. However, this research did not aim to explore collaboration network cases when two or more types of linkages are responsible to develop radical innovation at the same time. Therefore, this study opens research opportunities to explore the radical innovation phenomenon through more complex collaboration networks with three or more players simultaneously (e.g. firm, plus client, plus supplier).

Market-shaping literature present several specific activities firms can adopt to shape the market (Flaig et al., 2021b), as well as different firms' behaviour guided by strategic orientation (proactive vs. reactive) in favouring to shape the market (Kohli & Jaworski, 2023; Randhawa et al., 2021). This study focused on specific aspects (collaboration networks and radical innovation) rather than broad behaviour elements, providing deeper advances and knowledge in these specific elements. The choice was also consistent with the Evolutionary Theory of Innovation scope, considering the data availability. Then, future studies could follow the same narrowing position providing deeper knowledge about other manners firms can shape markets.

Research design limitations also must receive attention. Secondary data-based research is essentially limited by what is already available (Henningsen & Henningsen, 2019), with scarce possibility to add new data. Therefore, the constructs to be included in the regression analysis are conditioned to database availability. Then, future studies could adopt different research design such as qualitative research or rely on primary data to gather diverse insights.

Data is limited by the format and source. The fact that data is quantitative limits the concepts to the numbers registered. For example, the competitive intensity has been defined in literature in diverse aspects, such as i) the volume of players in the market, uncertainty of competitors strategy (Challagalla et al., 2014), ii) how offensive competition is perceived (competitors aggressiveness) (Jayachandran et al., 1999; Martin & Javalgi, 2016), iii) how fast is competitors response to organization's actions (Keskin et al., 2021) or iv) how difficult is for new players to get into the market. Another aspect was the few possibilities of control variables. This study was able to rely on GDP and pertaining to emergent countries group as control variables. Future studies could explore, for example, the industry as control variables, once some firm activities are known to be innovation intensive and it might influence in the market dynamics (Ojha et al., 2020). Regarding the source, data was collected from OEDC iLibrary

databases. Therefore, the countries that composed the sample were mostly OECD members. If data included more non-members countries, maybe the results could provide different insights

The longitudinal characteristic was focused on the consistence of the effects. Future studies could explore how the variables changes with time, once the theories used share assumptions of dynamism of firms behaviour and market changes (Meirelles, 2009; Möller et al., 2020; Nelson & Winter, 1977; Nenonen & Storbacka, 2018).

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APPENDIX I – COUNTRIES INCLUDED IN EACH WAVE

Country Lable	Country Name	Source	Wave 2013	Wave 2015	Wave 2017	Wave 2019	Wave 2021	Wave 2023	Lenght
ARG	Argentina	National Dynamics of Employment and Innovation Survey						2019-21	3
ARG_MANUF	Argentina (manufacture)	National survey on Employment and Innovation Dynamics				2014-16			3
AUS	Australia	Business Characteristics Survey (BCS)	2010-11 (financial year)	2012-13 (financial year)	2014-15 (financial year)	2016-17 (financial year)	2018-19 (fiscal year)	2020-21 (financial year)	1
AUT	Austria	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
BEL	Belgium	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
BGR	Bulgaria	Results of the community innovation survey Eurostat database and national innovation survey	.					2018-20	3
BRA	Brazil	Technological Innovation Survey (PINTEC)	2006-08	2009-11	2012-14		2015-17		3
CAN	Canada	Survey on Innovation and Business Strategy (SIBS)	2007-09	2010-12		2015-17	2017-19	2017-19	3
CHE	Switzerland	Survey on Innovation Activities in the Swiss economy	2009-11	2010-12	2012-14	2014-16	2016-18	2018-20	3
CHL	Chile	Innovation Survey	2009-10	2009-10	2013-14	2015-16	2017-18	2019-20	2
CHN	China	Chinese Innovation Survey	2004-06		2013-14	2014-16	2018		3/1
COL_M	Colombia (manufacture)	Survey of Development and Technological Innovation in the Manufacturing sector	.	2011-12	2013-14	2015-16			2
COL_S	Colombia (services)	Survey of Development and Technological Innovation in the Service sector	.	2012-13	2014-15	2016-17			2
CYP	Cyprus	Results of the community innovation survey Eurostat database and national innovation survey	.					2019-20	3
CZE	Czech Republic	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
DEU	Germany	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
DNK	Denmark	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3

ESP	Spain	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
EST	Estonia	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
FIN	Finland	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
FRA	France	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
GBR	United Kingdom	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
GRC	Greece	Results of the community innovation survey Eurostat database and national innovation survey	.	2010-12	2012-14	2014-16	2016-18	2018-20	3
HRV	Croatia	Results of the community innovation survey Eurostat database and national innovation survey	.					2018-20	3
HUN	Hungary	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
IND	India	Indian National Innovation Survey		2010-11				2019-20 (financial years)	2
IRL	Ireland	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
ISL	Iceland	Results of the community innovation survey Eurostat database and national innovation survey	2008-10			2014-16	2016-18	2018-20	3
ISR	Israel	The Israel Innovation Survey	2006-08	2010-12			2016-18		3
ITA	Italy	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2017-19	2018-20	3
JPN	Japan	Japanese National Innovation Survey (J-NIS)	2009-11 (financial years)	2009-11 (financial years)	2012-14 (fiscal years)	2015-17	2017-19/2018-20	2019-21	3
KOR	Korea, Republic of	Korean Innovation Survey	2005-07	2011-13	2013-15	2015-17	2016-18	2017-19 / 2018-20	3
LTU	Lithuania	Results of the community innovation survey Eurostat database and national innovation survey	.		2012-14	2014-16	2016-18	2018-20	3
LUX	Luxembourg	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16		2018-20	3
LVA	Latvia	Results of the community innovation survey Eurostat database and national innovation survey	.	2010-12	2012-14	2014-16	2016-18	2018-20	3
MEX	Mexico	Survey of Technological R&D (ESIDET)	2008-09	2010-11	2012/13				2

MLT	Malta	Results of the community innovation survey Eurostat database and national innovation survey	.					2018-20	3
NLD	Netherlands	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
NOR	Norway	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
NZL	New Zealand	Business Operation Survey (BOS)	2009-11 (financial years)			2015-17 (financial years)	2017-18 (financial years)	2019-20 (financial years)	2
POL	Poland	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14 (financial years)	2014-16	2016-18	2018-20	3
PRT	Portugal	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
ROU	Romania	Results of the community innovation survey Eurostat database and national innovation survey	.					2018-20	3
RUS	Russia	Russian Innovation Survey	2009-11	2011-13	2012-14	2014-16	2019		2
SVK	Slovakia	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
SVN	Slovenia	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
SWE	Sweden	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
TUR	Turkey	Results of the community innovation survey Eurostat database and national innovation survey	2008-10	2010-12	2012-14	2014-16	2016-18	2018-20	3
URY	Uruguay	Uruguayan Innovation Survey						2019-21	3
USA	United States	Business R&D and Innovation Survey (BRDIS) and Annual Business Survey	2008-10		2012-14	2015-17	2016-18	2017-19	3
ZAF	South Africa	South African Business Innovation Survey	2005-07				2014-16		3

SOURCE: The author, 2025, based on (OECD, 2022).

APPENDIX II – INDICATORS PAIRING IN EACH WAVE

IndicatorID	Lable	Description	Wave 2013 (53)	Wave 2015 (41)	Wave 2017 (33)	Wave 2019 (36)	Wave 2021 (40)	Wave 2023 (43)
1	INNOV.PLUS	Innovative firms (product/process or ongoing/abandoned or organisational/marketing), as a percentage of total firms		1	1	1	2	2
2	INNOV	Innovative firms (product/process or organisational/marketing), as a percentage of total firms	6 to 9 listed 6 to 8	2	2	2	1	1
3	INNOV.TECH	Product and/or process innovative firms (regardless of organisational or marketing innovation), as a percentage of total firms		3	3	3		
4	INNOV.TECH.PLUS	Product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organisational or marketing innovation), as a percentage of total firms	1 to 5 listed: 1 to 3	4	4	4		
5	INNOV.PROD	Product innovative firms (regardless of any other type of innovation), as a percentage of total firms		5	5	5	3	3
6	INNOV.PROC	Process innovative firms (regardless of any other type of innovation), as a percentage of total firms		6	6	6		
7	INNOV.ORG	Organisation innovative firms (regardless of any other type of innovation), as a percentage of total firms		7	7	7		
8	INNOV.MKT	Marketing innovative firms (regardless of any other type of innovation), as a percentage of total firms		8	8	8		
9	INNOV.TECH.ONLY	Product and/or process innovative firms only, as a percentage of total firms	42 to 44	9	9	9		
10	INNOV.NONTECH.ONLY	Organisation and/or marketing innovative firms only, as a percentage of total firms	45 to 47	10	10	10		
11	INNOV.TECHNONTECH	Product and/or Process AND Marketing and/or Organisational innovations only, as a percentage of total firms	48 to 50	11	11	11		
12	INNOV.BUSIN	Business process innovative firms, as a percentage of total firms					8	8

13	INNOV.BUSIN.OPE	Business process innovative firms with innovations in the production of goods or services, as a percentage of total firms					9	9
14	INNOV.BUSIN.DIST	Business process innovative firms with innovations in distribution and logistics, as a percentage of total firms Business process innovative firms with innovations in marketing and sales, as a percentage of total firms					10	10
15	INNOV.BUSIN.MKT	Business process innovative firms with innovations in marketing and sales, as a percentage of total firms					11	11
16	INNOV.BUSIN.ICS	Business process innovative firms with innovations in information & communication systems, as a percentage of total firms					12	12
17	INNOV.BUSIN.ADM	Business process innovative firms with innovations in administration & management (accounting, external relations, human resource management), as a percentage of total firms					13	13
18	INNOV.BUSIN.OWN	Business process innovative enterprises that developed processes only on their own, as a percentage of total firms					14	14
19	INNOV.GOODS.INNOV	Product innovative firms innovating in goods, as a percentage of product innovating firms		12				
20	INNOV.GOODS.TOTAL	Product innovative firms (innovation of goods), as a percentage of total firms					4	4
21	INNOV.GOODS.ONLY	Product innovative firms innovating in goods ONLY	33 to 35					
22	INNOV.SERV.INNOV	Product innovative firms innovating in services, as a percentage of product innovating firms		13				
23	INNOV.SERV.TOTAL	Product innovative firms (innovation of services), as a percentage of total firms					5	5
24	INNOV.SERV.ONLY	Product innovative firms innovating in services ONLY	36 to 38					
25	INNOV.GOODSANDSERV	Product innovative firms innovating in Goods AND Services	39 to 41					
26	INNOV.PROD.OWN	Product innovative enterprises that developed products only on their own, as a percentage of total firms	13				6	6
27	INNOV.SERV.OWN	Product innovative firms that developed service innovations in-house	14					

28	INNOV.GOODS.EXT	Externally developed goods innovation, as a percentage of firms innovating in goods	15	14				
29	INNOV.SERV.EXT	Externally developed services innovation, as a percenatage of firms innovating services	16	15				
30	PROD.NEWTOMARKET	Product innovative firms with innovations that were new to the firm's market, as a percenatge of total firms		16	12	12	7	7
31	REDACTIVE	R&D active product and/or process innovative firms, including ongoing or abandoned innovation activities, as a percentage of product and/or process (including ongoing or abandoned) innovative firms		17	13	13	15	15
32	PUBSUP.PRODINNOV	Firms receiving public support for innovation, , as a percentage of product and/or process (including ongoing or abandoned) innovative firms	51 to 53	18	14	14		
33	PUBSUP.TOTAL	Firms receiving public support for innovation, as a percentage of total firms				15	18	18
34	TAXRELIEF	Firms receiving tax relief for R&D or other innovation activities, as a percentage of innovation-active firms					16	16
35	GOVFUND	Firms receiving government funding for innovation (including R&D and excluding contracts for goods and services), as a percentage of innovation-active firms					17	17
36	COOP	Firms co-operating on innovation activities, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organisational or marketing innovation).	17 and 19	19	15	16	19	19
37	COOP.SUPPLIER	Firms co-operating on innovation activities with suppliers, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organisational or marketing innovation).	21 and 21	20	16	17		
38	COOP.CLIENTS	Firms co-operating on innovation activities with clients (private and/or public sector), as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organisational or marketing innovation).	22 and 23	21	17	18		

39	COOP.HIGHORGOV	Firms co-operating on innovation activities with higher education or government institutions, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organisational or marketing innovation).	24 and 25	22	18	19		
40	COOP.NATONLY	Firms engaged in national collaboration only, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organisational or marketing innovation).	26	23	19	20		
41	COOP.INTERNAT	Firms engaged in international collaboration, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organizational or marketing innovation).	27 and 28	24	20	21		
42	COOP.PRIVATEOUT	Firms co-operating on innovation activities with private business enterprises outside the enterprise group, as a percentage of innovation active firms					20	20
43	COOP.INSIDE	Firms co-operating on innovation activities with enterprises within the enterprise group, as a percentage of innovation active firms					21	21
44	COOP.HIGH	Firms co-operating on innovation activities with universities or other higher education institutions, as a percentage of innovation active firms					22	22
45	COOP.PUBRED	Firms co-operating on innovation activities with public R&D institutes, as a percentage of innovation active firms					23	23
46	COOP.CLIENTSPUB	Firms co-operating on innovation activities with clients or customers from the public sector, as a percentage of innovation active firms					24	24
47	COOP.NPO	Firms co-operating on innovation activities with non-profit organizations, as a percentage of innovation active firms					25	25
48	COOP.INTERNATFIRM	Firms co-operating on innovation activities with enterprises engaged in international collaboration, as a percentage of innovation active firms					26	26
49	MARKETRESOURCES	Firms citing market sources as highly important for innovation	11	25				
50	INSTITUTIONALRESOURCES	Firms citing institutional sources as highly important for innovation	12	26				

51	INTERNALSOURCES	Firms citing internal sources of information as 'highly important' for innovation, all firms	10					
52	PATENTS	Firms that applied for patents, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organizational or marketing innovation).		27	21	22	27	27
53	DESIGN	Firms that registered a design, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organizational or marketing innovation).		28	22	23	28	28
54	TRADEMARK	Firms that registered a trademark, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organizational or marketing innovation).		29	23	24	29	29
55	COPYRIGHTS	Firms that claimed copyrights, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organizational or marketing innovation).		30				
56	TRADESECRETS	Firms using trade secrets, as a percentage of product and/or process innovative firms, including abandoned or ongoing innovation activities (regardless of organizational or marketing innovation).		31				
57	PUBL.PROCUREMENT.TOTAL	Firms with public procurement contracts, as a percentage of total firms		32	24			
58	PUBL.PROCUREMENT.INNOV	Innovative firms with public procurement contracts, as a percentage of total innovative firms		33	25			
59	PUBL.PROCUREMENT.INNOV.TOTAL	Innovative firms with public procurement contracts, as a percentage of total firms		34	26			
60	PUBL.PROCUREMENT.NOTINNOV.TOTALNOT	Non innovative firms with public procurement contracts, as a percentage of total non-innovative firms		35	27			
61	PUBL.PROCUREMENT.INNOVPUB	Innovative firms with public procurement contracts, as a percentage of total firms with public procurement contracts		36	28			
62	INTERNATIONAL	Firms operating in international markets, as a percentage of total firms		37	29	25	30	30

63	INNOV.INTERNATIONAL.INNOV	Innovative firms operating in international markets, as a percentage of total innovative firms		38	30	26	31	31
64	INNOV.NOTINTERNAT	Innovative firms not operating in international markets, as a percentage of total innovative firms				27	34	34
65	INNOV.INTERNATIONAL.TOTAL	Innovative firms operating in international markets, as a percentage of total firms		39	31	30		
66	NOTINNOV.INTERNATIONAL	Non innovative firms operating in international markets, as a percentage of non-innovative firms		40	32	29	33	33
67	INNOV.INTERNATIONAL.INTER	Innovative firms operating in international markets, as a percentage of total firms in international markets		41	33	31	32	32
68	PRODINNOV.INTERNATIONAL	Product innovative firms operating in international markets, as a percentage of total product innovative firms				28		
69	REDEXP	R&D expenditure as percentage of total expenditures on innovation activities				32	37	40
70	TURNOVER.PROD	Share of turnover from new or significantly improved products				33	38	41
71	TURNOVER.NEWFIRM	Share of turnover from new or significantly improved products that are only new to the firm				34	39	42
72	TURNOVER.NEWMARKET	Share of turnover from new or significantly improved products that were new to the market				35	40	43
73	EMPLOYMENT	Employment in innovative firms (product/process or organizational/marketing), as percentage of total employment				36	35	38
74	EMPLOYMENT.INNOV	Share of persons employed in innovation-active firms in total employment					36	39
75	ENVIRONMENTAL	Innovative enterprises that introduced innovations with environmental benefits within the enterprise (i.e. within the business processes and supply chain) OR generated during the use of the enterprise's good and services by consumers or end users - with significant contributions to environmental protection, as a percentage of innovative firms						35

76	ENVIRONMENTAL.WITHIN	Innovative enterprises that introduced innovations with environmental benefits within the enterprise (i.e. within the business processes and supply chain) - with significant contributions to environmental protection, as a percentage of innovative firms						36
77	ENVIRONMENTAL.INUSE	Innovative enterprises that introduced innovations with environmental benefits generated during the use of the enterprise's good and services by consumers or end users - with significant contributions to environmental protection, as a percentage of innovative firms						37

SOURCE: The author, 2025, based on (OECD, 2022). The numbers in parenthesis, aside the waves' period, are respective to the volume of indicators present in each wave.