Effects of Absorptive Capacity and Innovation Spillover on Manufacturing Flexibility

ABSTRACT

Purpose

Shifting demand and ever shorter production cycles pressure manufacturing flexibility. Although the literature has established the positive effect of the firm's absorptive capacity on manufacturing flexibility, the separate role of the innovation competencies of exploitation and exploration in such a relation is still under-investigated. In this study, we examine how these competencies affect manufacturing flexibility.

Design/methodology/approach

We use survey data from 370 manufacturing firms and analyze them using covariance-based structural equation modeling (CB-SEM).

Findings

The results indicate that absorptive capacity has a strong, positive, and direct effect on exploitative and exploratory innovation competencies, proactive and responsive market orientations, and manufacturing flexibility. Our findings also demonstrate that the exploratory innovation competencies mediate the relation between responsive market orientation and manufacturing flexibility. Essentially, these exploitative innovation competencies produce a direct positive effect on manufacturing flexibility while simultaneously being a vehicle for absorptive capacity's indirect effects on it. An exploration innovation strategy does not significantly affect manufacturing flexibility.

Originality/value

This study contributes by combining key strategic features of firms with manufacturing flexibility, while providing new empirical evidence of the mediation of the exploratory innovation competencies in the relation between responsive market orientation and manufacturing flexibility.

Keywords: dynamic capabilities, absorptive capacity, market orientation, innovation competence orientation, manufacturing flexibility.

JEL: M11; M18; L60.

1. INTRODUCTION

Manufacturing flexibility has become relevant to achieving a competitive advantage for firms in the contexts of volatile demand and high competition (Ojha *et al*., 2015; Patel *et al*., 2012; Tamayo-Torres *et al*., 2014). Furthermore, manufacturing flexibility plays an important role in addressing stakeholders' expectations and to achieve more sustainable performance (Sharma & Sushil, 2002; Sushil 2014). Among the capabilities important for the development of manufacturing flexibility are absorptive capacity and ambidexterity (Patel *et al*., 2012). While absorptive capacity supports the recognition, assimilation, and transformation of new knowledge, ambidexterity uses such knowledge for both exploitation and exploration (Patel *et al*., 2012). Patel *et al*. (2012) states that each firm's absorptive capacity is context contingent and unique that enhances the firm's returns through the better alignment of manufacturing flexibility with the environment. Furthermore, they find that ambidexterity is also key to achieving increased returns from manufacturing flexibility. The suggested mechanism that explains this result is that ambidexterity helps to channel the firm's learning efforts by harmonizing the optimization of existing routines and processes with the development of new routines and processes, which thus ensures continuity (Mishra, et al., 2014).

Building on Patel *et al*. (2012) work, this study aims to evaluate to which extent the separate capabilities of organizational absorptive capacity, innovation reliability strategy and innovation variability strategy affect manufacturing flexibility and the discussion of the underlying mechanisms of such effects. Previous research identified the manufacturing flexibility mediating role on the relation between knowledge creation and business and operational performances (Pinheiro *et al*., 2020), however, the study of manufacturing flexibility has a dependent variable and of the role of absorptive capacity, exploitative and exploratory innovation competencies, and proactive and responsive market orientations are still underexplored. Thus the central research question here is: how do exploitative and exploratory innovation competencies separately affect manufacturing flexibility when taking into account the role of absorptive capacity? While there are still very few studies that focus on the relations between

ambidexterity and manufacturing constructs, Tamayo-Torres et al. (2017) find a significant connection between ambidexterity and manufacturing performance (quality, delivery, cost, and flexibility).

This connection makes the separate relations between innovation competencies (exploitative and exploratory) and manufacturing flexibility predictable and worth analyzing separately. Martini et al. (2015) underlines the importance of the structural separation of initiatives to explore and exploit in order to develop innovation. To the best of our knowledge, this study is the first to address the separate effects of exploitative and exploratory innovation competencies on manufacturing flexibility, which appears to be a literature gap, while also accounting for the firm's absorptive capacity. This study addresses Ketchen and Guinipero's (2004) request to link strategic management to the perspectives of operations management.

A model including absorptive capacity, market orientation (responsive-proactive), innovation competences orientation (exploitation-exploration) and manufacturing flexibility is presented, discussed and tested, to research how paradoxical strategic orientations (responsiveness-proactivity and exploitation-exploration) depend on absorptive capacity and affect manufacturing flexibility. Additionally, the study of the mediation role of market and innovation competences orientations and the contingency effects of firm size on the model's relations is performed, in order not only to render hypotheses testing more consistent (Malhotra *et al*., 2014) but also to understand how firm size affects the model's relations. The advantage of a model aggregating several constructs simultaneously lies in the illustration of the tensions among them while providing further insight over their relative importance for manufacturing flexibility. The constructs of choice in this study are complementary: while absorptive capacity captures the organizational behavior toward acquiring, sharing and transforming knowledge from external sources, market orientation (responsive-proactive) relates to the firm's focus on costumers to create new services and product ideas, and innovation competences orientation (exploitation-exploration) expresses the strategic orientations of the innovation activities.

This study defines an innovation reliability strategy as the set formed by a responsive market

orientation and the exploitation competence, and an innovation variability strategy as the set formed by a proactive market orientation and exploration competence. The innovation reliability strategy is responsible for the alignment of the firm with its environment (adopting market characteristics), while the innovation variability strategy is responsible for the adaptability of the firm to its environment (creating market change). The terminologies for these strategies come from Mom *et al.* (2007). The conceptual model presented in this study interlinks absorptive capacity, innovation flexibility, and manufacturing flexibility.

This study contributes to the literature in several ways. First, to the operations literature by offering further probing the relations between the strategic and operations perspectives, which follows the call of Ketchen and Giunipero (2004). We also advance the research on information-processing antecedents of manufacturing flexibility (Ojha *et al*., 2015). A further contribution to the operations literature is the added empirical evidence that involves a multidimensional operationalization of manufacturing flexibility, which is in line with its latest conceptualizations (Pérez Pérez *et al*., 2016; Rogers *et al*., 2011; Zhang *et al*., 2003). Second, this study contributes to the literature of ambidexterity by probing the separated direct effects of strategies to exploit and explore innovation on manufacturing flexibility and their mediation role in the relation between absorptive capacity and manufacturing flexibility. Finally, it adds further rationale and evidence to the rarely examined link between absorptive capacity and exploratory orientations (Lane *et al*., 2006) that responds to the calls of Adler *et al*. (2009) and Andriopoulos and Lewis (2009) to examine ambidexterity in an operations context.

This study contends that the existence of an externally-oriented open learning culture in the form of absorptive capacity positively contributes not only to the exploitative and exploratory innovation competencies, but also to the development of manufacturing flexibility. Furthermore, it contends that such a contribution is direct and indirect through both innovation strategies.

In the section that follows, we present the theoretical foundations. In the third section, we present the model and construct hypotheses. That section is followed by a presentation of the methods and results. The study concludes with a discussion of the results, implications for both

theory and practice, and its limitations and possible work routes.

2. THEORETICAL BACKGROUND

This study combines two theoretical lenses: the knowledge based view of the firm (Grant, 1996) that highlights knowledge as the most strategically important firm resource, and the dynamic capabilities perspective (Teece *et al*., 1997) that refers to an organization's ability to change its operations in an efficient and responsive manner to the environment. While a capability generally designates a certain functional area of the firm that enables it to engage in specific actions, a competence refers to the knowledge, skills, and resources that shape the firm's ability to deliver superior customer value (Day, 1994). In simpler words, a competence designates the proficiency with which a capability is put into practice. A dynamic capability enables a firm to change its core capabilities (Wang and Ahmed, 2007). The term was defined by Teece *et al*. (1997) as the firm's ability to integrate, build, and reconfigure internal and external competences to rapidly address changing environments. Recent studies have defined it as the abilities to reconfigure the firm's resources and routines in a manner envisioned by management (Zahra *et al*., 2006). Most dynamic capabilities involve knowledge and time that address the need to develop internal and external activities that aim to change core capabilities to gain benefits from the firm's competitive advantage and performance. Wu (2006) theoretically and empirically concludes that resources affect performance rather indirectly through dynamic capabilities such as innovation and the speed of the market's response but also through operational capabilities such as manufacturing efficiency and flexibility.

Malik and Kotabe (2009) define manufacturing flexibility as a dynamic capability because of its effect on firm performance in a dynamic world. Some studies have recognized manufacturing flexibility as an important responsive and proactive type of strategic orientation (Brettel *et al*., 2016). Thus, it is a capability potentially enabling not only a response to the environment but also an attempt to shape it. This study regards manufacturing flexibility as a

core capability of the firm over which absorptive capacity as well as innovation flexibility have greater influence.

2.1. *Absorptive Capacity*

The general perspective of learning as building a capability closely relates to the more specific construct of absorptive capacity that is the firm's ability to identify, assimilate, and explore the knowledge gained from external sources, as defined by Cohen and Levinthal (1989). Absorptive capacity represents a background structure that enables the firm to exploit and explore acquired, transformed, and newly created knowledge (Cohen and Levinthal, 1994). In order to exploit externally acquired knowledge, firms need to translate it into usable forms that are oriented to the market to reach their goal to build competitive advantage through innovation and strategic flexibility (Zahra and George, 2002). This study regards absorptive capacity as a higher order dynamic capability common to all firms (Wang and Ahmed, 2007) and capable of enhancing other core capabilities, such as manufacturing flexibility as well as market and innovation related capabilities.

2.2. Manufacturing Flexibility

Manufacturing flexibility is a strategic capability that enables firms to achieve competitive advantage in the marketplace (Jain *et al.*, 2013). Zhang *et al*. (2003) define it as the firm's capability to address increasing variety in demand expectations without excessive costs, time, or organisational disruptions as well as performance losses. A more specific and recent definition deems it as "the ability of the manufacturing function to make adjustments needed for coping with environmental change with little penalty in time, effort, cost or performance" (Pérez Pérez *et al*., 2016, p. 3133). Slack (1983) and Gerwin (1993) have found that the strategic perspective of manufacturing flexibility is a response to certain forms of uncertainty. More recently,

D'Souza and Williams (2000) and Oke (2005) have linked manufacturing-based flexibilities to marketing-based flexibilities. Manufacturing flexibility is relevant for several firm outcomes such as acquiring resources and institutional support (Grewal and Tansuhaj, 2001), satisfying customers (Zhang *et al*., 2003), reconfiguring the supply chain (Pagell and Krause, 2004; Singh, *et al*., 2019), and meeting market demand (Anand and Ward, 2004).

Manufacturing flexibility is more recently seen as a combination and result of several dimensions (Jain *et al*., 2013; Zhang *et al*., 2003). Examples of such perspective can be found in Dreyer and Grønhaug (2004) and (Rogers *et al*., 2011). These authors defend the multidimensional character of flexibility as a condition for firms to face volatile environments, because of the value of the complementary role of its dimensions. Rogers et al. (2011) give the different practices of General Motors and Toyota in the eighties and nineties of the twentieth century, as an example. Although both companies had largely invested in advanced manufacturing technology to gain more flexibility, Toyota has taken the lead in the synergic and complementary use of each of its dimensions (product mix flexibility, routing flexibility, equipment flexibility, volume flexibility, labour flexibility, and supply management flexibility). Other authors studying these two firms have previously established this view (Milgrom and Roberts, 1995) by observing that Toyota gained more flexibility than General Motors by exploiting a deeper, more effective, level of synergy between the supply management, HR management and operations.

The challenge in developing manufacturing flexibility is expressed by the change-preservation paradox, the tension between the need to change manufacturing flexibility while preserving its purpose (Volberda, 1996). The tension emerges from the potentially quick obsolescence of equipment and technology the firm invested in with uncertain payoffs. Kara and Kayis (2004) argue that manufacturing flexibility requires considerable investments that push firms to allocate time and resources just to figure out the appropriate type of flexibility needed and how to achieve it.

2.3. Exploitation and Exploration

Market orientation and innovation competencies aims to recognise current market conditions as well as predict future market conditions (Day, 1994; Kohli and Jaworski, 1990; Slater and Narver, 1994). It also reflects the characteristics of a dynamic capability (Zahra, 2008). Market orientation requires the systematic use of generated knowledge to guide the recognition, understanding, creation, selection, implementation, and modification of strategy toward adaptation and response formulation to international markets (Hunt and Morgan, 1996). Baker and Sinkula (1999) give empirical support to the idea that a firm's market orientation enhances organisational innovativeness and new product success. The ability to gather and use information about the present and the future is what enables market orientation to relate and enhance exploitative as well as explorative innovation (Fang *et al*., 2012). This study sees the market as a driving force behind innovation. Lamore *et al*. (2013) provide evidence that responsive and proactive market orientations are positively related to R&D integration and argue that such conceptualisation would contribute to moving the marketing function to the R&D function. The concept of responsive and proactive market orientation originated from the criticisms raised against the more traditional perspective of the construct (customer-competitor view) as being more convenient as an expression of the exploitation-exploration dichotomy focused on in this study. Narver *et al*. (2004) argue that market orientation should be the basis of a firm's innovation. The authors state that firms more effectively lead when they focus on a superior understanding of their customers' needs (explicit and latent). A responsive market orientation is defined as the firm's activities to discover, understand, and satisfy customers' explicit needs, while proactive market orientation is defined as the firm's activities to discover, understand, and satisfy customer's implicit (herein latent) needs (Narver *et al*., 2004).

Furthermore, because innovation related ambidexterity is important to the firm's outcomes (Gibson and Birkinshaw, 2004), the orientations of innovation competencies is included in this study, given the interest to probe into their separate roles in the firm's innovation processes and eventual spillover effects into manufacturing flexibility. This orientation expresses the choices

over the orientation of innovation activities that can be regarded as different strategies. Atuahene-Gima (2005) states that the orientations of innovation competencies are different. While the exploitative innovation competencies expresses incremental refinements in the firm's existing innovation knowledge, skills, and processes, the exploratory innovation competencies expresses the more radical developments of such knowledge, skills, and processes.

Adler *et al*. (2009) first suggested that ambidexterity could facilitate the firm's simultaneous efficiency and adaptation in an operations context. Extending this argument, Patel *et al*. (2012) find that firms that pursue exploitation and exploration are more likely to obtain higher returns from manufacturing flexibility. Even if firms that rely on specific manufacturing technologies cannot immediately change their processes when a new technology becomes available, they must make the most of existing resources and processes (exploit) while planning for future changes (explore), as their current resources and processes depreciate (Ludwig and Pemberton, 2011).

2.4. Absorptive Capacity and Manufacturing Flexibility

Breaking up the internal inertia of firms involves anticipating the obsolescence of existing capabilities while creating new ones aligned with newer technological standards (Rosenbloom and Christensen, 1994). Braglia and Petroni (2000) examine the relation between knowledge levels and manufacturing flexibility in SMEs and find that firms have a specific behavior and a specific situational manner when combining resources and capabilities that they require to address their environment (Dias & Pereira, 2017). In such a combinatorial process, firms identify the maturity of managerial competence and organizational development as keys. Camuffo and Volpato (1996) argue that the technologies used by Fiat resulted from a wide diversity of sources such as learning, internal developments, external acquisitions, imitating competitors, and replicating and selecting capabilities. Dhir *et al*. (2020) also found organizational learning, knowledge integration, technological capability, and technology

relatedness to be essential in post-acquisition performance.

Technological adoption may not be adequately implemented without absorptive capacity. Firms with low levels of absorptive capacity may be limited in the development of adequate levels and types of manufacturing flexibility. Empirical evidence exists that supports the effect of absorptive capacity on the capability to implement new manufacturing practices and the identification of process innovations (Tu *et al*., 2006). Empirical support also exists for the link between absorptive capacity and the firm's collaboration with supply chain partners (Singh, *et al*., 2019). Higher levels of absorptive capacity in firms are associated with higher employee and cross-functional interactions that are necessary for the exchanges that lead to better organizational learning (Jansen, *et al*., 2005).

According to Patel *et al*. (2012), absorptive capacity is a learning capability that can explain differential firm behaviour. Specifically, and in relation to manufacturing flexibility, these authors argue that the role of absorptive capacity is to amplify the flexibility of the firm's response to demand and competitive and technological uncertainty by enabling it to more effectively analyse and interpret the information on changes that concern the operational environment and thus more effectively approach reconfiguration, realignment, and renewal of operational capabilities (Mishra, et al., 2014). Firms with higher levels of absorptive capacity are expected to increase the scope and mobility of manufacturing flexibility. They are also likely to rapidly address their product mix by being more effective in adapting to changes in demand so they can proactively respond to competitive landscape changes (Cohen and Levinthal, 1989) and to technological innovations (Cohen and Levinthal, 1994; Narasimhan, *et al*., 2006). Firms with lower levels of absorptive capacity are expected to respond less effectively to environmental changes and to less effectively use knowledge to manage manufacturing flexibility (Patel *et al*., 2012). Consequently, we propose the following hypothesis:

H_{1a}. *Absorptive capacity is positively associated with manufacturing flexibility.*

2.5. Absorptive Capacity, Market Orientations, and Innovation Competencies

Learning develops from at the level of an individual or small group up to a more advanced organisational learning (Brockman, 2013). Absorptive capacity is one of the capabilities necessary for learning (Sun and Anderson, 2010). Learning via the acquisition of knowledge is a central factor for both exploitation and exploration related internal activities (Mom *et al*., 2007).

It is defined as the firm's ability to follow and respond to changes in the marketplace while generating knowledge and disseminating information (Zahra, 2008). It is about engaging with customers to deliver their perceived needs in the present and the future (He and Wei, 2011). It requires a systematic use of generated knowledge to guide the recognition, understanding, creation, selection, implementation, and modification of a strategy toward adapting and formulating a response (Hunt and Morgan, 1996).

The non-narrow acquisition, sharing, and creation of knowledge through absorptive capacity should enhance market-related information. This information is useful for responsive and proactive market-orientation processes by amplifying possible combinations of knowledge for the firm. This study adopts the market-orientation construct of Narver *et al*. (2004) as a dual set of strategies: responsive market orientation that is the firm's process of discovering, understanding, and satisfying the expressed customer's needs; and proactive market orientation that is the firm's process of discovering, understanding, and satisfying the latent customer's needs. Separating these components is fundamental when also focusing on innovation (Narver *et al*., 2004), and thus useful for this study's conceptual model. The related hypotheses are:

H_{1b}. *Absorptive capacity is positively associated with a responsive market orientation.*

H_{1c}. *Absorptive capacity is positively associated with a proactive market orientation.*

2.6. Orientations of Innovation Competencies

The exploitative innovation competencies are the incremental refinements of the firm's existing innovative knowledge, skills, and processes, while the innovation competence of exploration

reflects more substantive overhauls of such knowledge, skills, and processes, (Atuahene-Gima,2005).

To Cohen and Levinthal (1994), higher absorptive capacity enables firms to forecast trends and take advantage of opportunities earlier than their competitors. This justifies its interest in the development of innovation activities. Absorptive capacity was shown to influence innovation (Tsai, 2001). Lane *et al*. (2006) finds that innovation is the main consequence of absorptive capacity. Anderson and Tushman (1990) show that absorptive capacity increases the speed and frequency of incremental innovation. They support this finding based on the argument that incremental innovation develops primarily from existing knowledge. Van den Bosch *et al*. (1999) show that absorptive capacity fosters incremental innovation through a deeper understanding of a narrow range of closely related topics. On the other hand, Lane *et al*. (2006) observe that the relation between absorptive capacity and radical innovation has received little attention despite the argument that radical innovation should involve novel combinations of existing technologies and know-how (Van den Bosch *et al*., 1999). Absorptive capacity focuses on non-narrow knowledge domains that can help fuel radical innovation (Lane *et al*., 2006). Firms with higher levels of absorptive capacity should more easily understand how to innovate their products or processes (Lane *et al*., 2006; Tu *et al*., 2006; Zahra and George, 2002). Therefore, absorptive capacity should also affect in a positive way the innovation competencies that underlie the incremental and radical innovations. This study hypothesizes that:

H_{1d}*: Absorptive capacity is positively associated with the exploitative innovation competencies.*

H_{1e}*: Absorptive capacity is positively associated with the exploratory innovation competencies.*

2.7. Market Orientation and Innovation Competencies

A firm's ability to gather and to use information about the present and the future is what relates market orientation to exploitation and exploration of innovation (Fang *et al*., 2012). More precisely, market orientation contributes knowledge to innovation that allows the firm to make appropriate use of it (Fang *et al.*, 2012), such as to innovate in consistently differentiated and novel ways.

Additionally, significant empirical evidence of the impact of market orientation on innovation characteristics and performance exists in the literature, in studies focusing on services as well as on manufacturing firms (Atuahene-Gima, 1995). Specifically, Atuahene-Gima (1995) discovered a positive and significant association between market orientation (customer-competitor) and the innovation-marketing fit, product advantage and inter-functional teamwork. He suggested that effective management of innovation activities can be achieved through market orientation. There is wide empirical evidence of the positive impact of market orientation on new product success. Baker and Sinkula (2005) concluded that empirical support for the positive impact of market orientation on new product success was transversal to the batch of papers under analysis. Market orientation (customer-competitor) was found to play a central role in enabling firms to be operationally and strategically efficient at the same time, by maintaining a dual exploitative and explorative role in the firm's competences (Atuahene-Gima, 2005). Atuahene-Gima (2005) found that exploiting existing product innovation competences (operational efficiency) and exploring new product innovation competences (strategic efficiency) required a positive and strong market orientation, while exploitation and exploration capabilities were, in turn, associated with incremental and radical new product innovation outcomes.

Evidence is also mounting over the market orientation (responsive-proactive view) impacts on innovation-related constructs which suggests that both market orientation views (customer-competitor and responsive-proactive) are consistent. Previous research showed the association of market orientation and innovation (Laforet, 2008). Another study found that responsive and proactive market orientation are related to exploitative and explorative innovation, respectively

(Li *et al*., 2008). These authors have reported a significant positive effect of responsive market orientation on incremental innovations and a significant positive effect of proactive market orientation on radical innovations. Such findings improved the understanding of how responsive and proactive modes of market orientation can affect incremental and radical innovation (to which exploitation and exploration innovation competences are required). Fang *et al.* (2012) corroborate the positive effect of market orientation (responsive-proactive) on exploitation and exploration innovation activities. Consequently, the hypotheses are:

H_{2a}. *A responsive market orientation is positively associated with the exploitative innovation competencies.*

H_{2b}. *A proactive market orientation is positively associated with the exploratory innovation competencies*.

2.8. Exploitative and Exploratory innovation competencies

Lavie and Rosenkopf (2006) state that firms must explore new possibilities for adapting to future environmental changes as well as exploiting existing capabilities in order to compete in dynamic markets. Whereas exploitation is more associated with refinement and efficiency, exploration is more related with variation, experimentation and higher risk (March, 1991); while exploitation is implemented through activities that aim to establish standardized processes and can be associated with a short-term perspective, exploration is about creating new knowledge and entirely new ways to solve problems, being associated with the longer term (March, 1996); exploitation is associated with experimental refinement and reuse of existing routines, while exploration is associated with changes to established processes (Baum *et al*., 2000).

Strategic behavior aims at keeping production costs under control and reducing throughput times while adequately responding to variations in demand requisites (Damanpour & Gopalakrishnan, 2001; Dinesh & Sushil, 2019; Gupta, 2018). This behavior means firms are expected to use the less costly exploitation of existing capabilities in the short term, and the

costlier exploration of new ideas in the long term (Miller, *et al*., 2006). Exploitation and exploration configure different strategic options for the firm to respond to competitors (Brion *et al*., 2010; Li *et al*., 2008). One of the ways to implement exploitation is the elimination of deficient tasks and the search for new routes (Levinthal and March, 1993), while for the case of implementing exploration a longer term perspective must be at play in order to find alternatives to improve what exists (March, 1991).

Being a tool that responds to competitors, innovation competencies are expected to be related to the specificities of their firm's production systems and to be developed in line with the viable, existing, technical possibilities within the firm. Even so, while the exploitative innovation competencies should sustain incremental innovation that is more easily produced by the current firm's manufacturing technology, the exploratory innovation competencies is expected to sustain more radical innovation that is possibly not so straightforward to produce with the existing firm's manufacturing technology. However, manufacturing flexibility should be able to adapt to both in due course and develop in a way as to be able to timely and cost effectively produce the innovations coming out of both types of competencies. Therefore, while innovation competencies in manufacturing firms may have different limitations, they should have a positive effect on manufacturing flexibility: the more innovative the firm, the greater the diversity of products it should produce and the more its production processes must adapt and become flexible (Haleem, et al., 2018).

Some evidence already exists to support this conjecture: Tamayo-Torres *et al*. (2011) find that higher levels of exploitative and explorative forms of knowledge are associated with higher levels of manufacturing flexibility and that this relation is amplified under more turbulent environmental conditions and with higher organizational learning levels. This relation indicates that an association should exist between the orientations of innovation competencies and manufacturing flexibility. Ambidexterity promotes flexibility in the firm's response to environmental changes affecting demand, to changes in the competitive landscape and technological changes as well (Patel *et al*., 2012). While firms with higher ambidexterity levels

are expected to frequently probe customer's needs and respond creatively (Lubatkin, *et al*., 2006), firms with lower levels of ambidexterity can lean toward incremental operational innovations, excessively focusing on exploitation and thus more often missing opportunities to enhance their manufacturing flexibility (Patel *et al*., 2012). Singh and Khamba (2014), found that innovation competences are drivers for supply chain management capabilities improvements. A capability of exploitation and exploration can enable the development of manufacturing responses affecting flexibility, for example through a modified product mix (Patel *et al*., 2012). Firms with higher ambidexterity (balanced exploitation-exploration activities) are able to refine existing processes as well as develop new ones affecting manufacturing flexibility (Patel *et al*., 2012). Consequently, similar relations can be expected regarding the separate impacts of innovation competences exploitation and exploration on manufacturing flexibility. Therefore, this study hypothesizes that:

H_{3a}. *The exploitative innovation competencies are positively related to manufacturing flexibility.*

H_{3b}. *The exploratory innovation competencies are positively related to manufacturing flexibility.*

If market orientation enhances the orientation of innovation competencies and the latter positively effects manufacturing flexibility, there could be indirect effects of market orientation on manufacturing flexibility because of the orientations of the innovation competencies. This possibility generates the following hypotheses:

H_{4a}. *Exploitative innovation competencies mediate the positive relation between a responsive market orientation and manufacturing flexibility.*

H_{4b}. *Exploratory innovation competencies mediate the positive relation between a proactive market orientation and manufacturing flexibility.*

Figure 1 presents the configuration of the main hypotheses in the structural model.

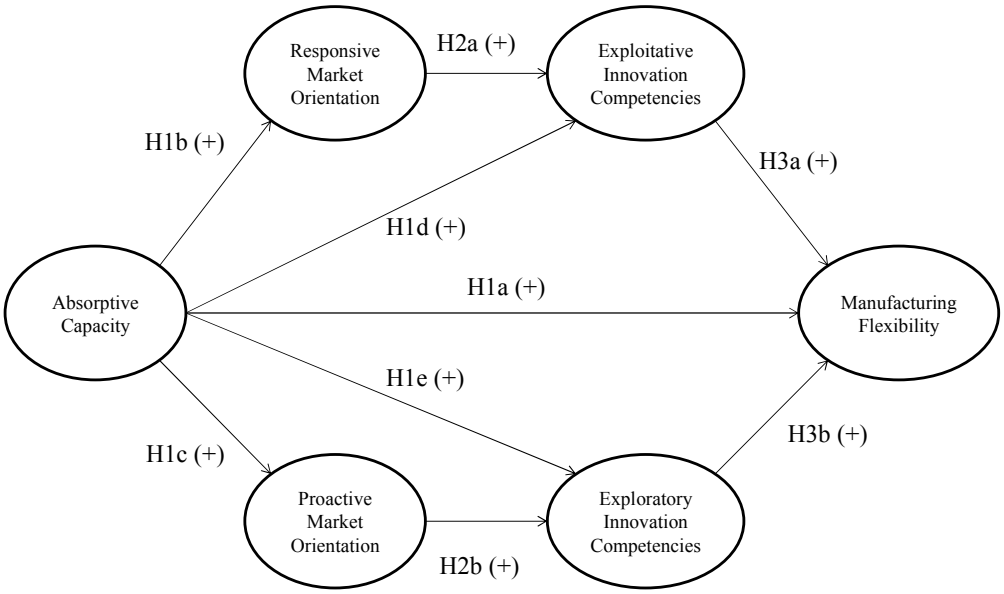

Fig.1. Conceptual Model

3. METHODOLOGY

3.1. Sample and data

An online survey aimed at CEOs and CFOs was sent by email to the 3,728 registries of Portuguese manufacturing firms with 20 or more employees available in the Kompass Database (Kompass, 2015). The online questionnaire guaranteed the anonymity of the respondents. After three sequential reminders, out of 3,728 firms, a total 515 responses were obtained for a response rate of 14%. These responses resulted in 370 fully completed questionnaires. A wide variety of industries (e.g., food and beverages, textiles, paper and paper products, rubber and plastic products, chemical products, machinery and equipment, automotive) were represented in the sample. Most of the respondents held the position of CEO (65.1%), and the remaining were CFOs. The firms' details are as follows. Regarding the firms age, 6% of the firms had 10 years of activity or less, 28% were between 11 and 25 years of activity, 54% were between 26 and 65 years of activity, 12% had more than 66 years of activity. In relation to the firm size 45% had between 20 and 49 employees, 45.4% between 50 and 249 employees, and 9.5% of the firm had 250 or more employees. The sales were between

154.886 EUR and 10.866 million EUR a year.

3.2. Measures

Scale items for all constructs were adapted from previous studies (See appendix). During the pre-test phase, conducted with eight CEO and CFO, it was suggested to uniform the use of 7-point Likert type scales. Although some of the original scale used a 5-point scale, this adaptation does not affect the measurement quality for analytical tools as structural equation models (Dawes, 2008). As such, all variables were measured using 7-point Likert type scales (1= "strongly disagree" to 7= "strongly agree"). Absorptive capacity was operationalized as a second-order factor that consists of three first-order factors: knowledge acquisition; knowledge sharing; and knowledge creation. Knowledge acquisition was measured using three items adopted from Jansen *et al*. (2006) and Jaworski and Kohli (1993) that reflect the ability to acquire external knowledge. Knowledge sharing was measured through three items adopted from Jaworski and Kohli (1993) that capture the ability to share knowledge among employees and within the firm. Finally, knowledge creation was measured through four items taken from Pavlou and El Sawy (2006), and Flatten *et al.* (2009) that reflect the ability of the firm's employees to learn from external and internal knowledge to produce new ideas.

Manufacturing flexibility was operationalized as a second-order factor that consisted of six first-order factors: product-mix flexibility, routing flexibility, equipment flexibility, volume flexibility, labor flexibility, and supply chain flexibility. All first-order factors were measured using three items adapted from Rogers *et al*. (2011).

Responsive and proactive market orientation were measured using five and three-item scales, respectively, that were adapted from Narver *et al*. (2004). These items capture the ability of the firm to observe and retain a customer's expressed, as well as latent, needs. Exploitative and exploratory innovation competencies were measured using five items each adopted from Atuahene-Gima (2005). These items express the innovation competencies over a period of five years to assess consolidated practices.

4. ANALYSIS AND RESULTS

To test our model we used Covariance Based –SEM (CB-SEM). Since our conceptual model is a complex model with mediation effects and second order factors. We use CB-SEM because it allows: simultaneous and complete tests of all relationships in the model; specific, hypothetically causal links to be incorporated into a logical chain of relationships (Kline 2015) such as the mediation effects; to test hypotheses at a higher level of abstraction. In addition, SEM can differentiate between observed and latent variables (Kline 2005) whereas other methods, for example, multiple regression analysis do not.

4.1. Measurement scale validity and reliability

To assess the reliability and validity of the constructs we performed a confirmatory factor analysis (CFA) that used the maximum likelihood (ML) estimation. We used AMOS 22 to execute the CFA. The fit indices showed that the measurement model fit the data satisfactorily with measures of $\chi 2$= 1529.32 (df =757; $p < 0.001$); $\chi 2$ /df= 2.02; CFI = 0.92; TLI = 0.92; IFI = 0.92; RMSEA = 0.053, p-close = 0.131; and SRMR = 0.067 (Hair *et al.*, 2010; Kline, 2015).

All factor loadings were statistically significant ($p < 0.01$) which established item reliability (see Appendix 1). The composite reliability (CR) values were well above 0.70 (Bagozzi and Yi, 1988) for all constructs (see Table 1) which demonstrated internal consistency. The average variance extracted (AVE) for each construct was greater than 0.5 (Bagozzi and Yi, 1988). This AVE indicated that all constructs had convergent validity. The square root of the AVE of each construct (shown on the diagonal of Table 1) was higher than the construct's highest correlation with any other construct (Fornell & Larcker, 1981), which indicated discriminant validity.

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4.2. Common Method Bias

To assess the effect of common method bias (CMB), the unmeasured latent factor test (Podsakoff *et al*., 2003) was performed. The estimated common variance that was obtained by squaring the unstandardized common loadings of the common latent factor was 34.8% and did not account for more than 50% of the total variance. Additionally, the introduction of the common latent factor did not greatly affect most of the standardized loadings on the items and had a top change of 0.19 (one item only), which was below the 0.20 threshold in Aiken *et al*. (1991). The average change in the standardized item loadings before and after the introduction of the common latent factor was 0.08, and the median change was 0.08 as well. Moreover, the CFA for a single-factor model on all the items that were loaded showed a poor fit ($\chi2$ = 5717.1, $\chi2$ /df= 6.98, CFI= 0.49, TLI= 0.48, IFI= 0.45, SRMR= 0.26, and RMSEA= 0.127). If the common method variance was responsible for the relation among the constructs, this one-factor model would fit the data well (Mossholder *et al*., 1998). Taken together, the results show that the CMB is not a likely threat in this study.

4.3. Main Hypotheses Tests

We tested all hypotheses with SEM and a ML estimation that used AMOS 22. The structural model presented a good fit to the data with $\chi2$ = 1531.7 (df =759; $p < 0.001$); $\chi2$ /df= 2.02; CFI = 0.92; TLI= 0.92; IFI= 0.92; RMSEA= 0.053, *p-close*= 0.135; and SRMR = 0.069 (Kline, 2015).

The structural model explained 33% of the variance in the manufacturing flexibility. Table 2 presents the test results for the main hypotheses. The results indicate that seven out of the nine

main hypotheses are supported.

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Insert table 2 here

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The relation between absorptive capacity and manufacturing flexibility is positive and statistically significant (β= 0.334, p< 0.001). Thus, hypothesis H_{1a} is supported. The results show that absorptive capacity has a positive and significant relation with a responsive market orientation (β= 0.619, p < 0.001) and with a proactive market orientation (β= 0.611, p < 0.001). These results support hypotheses H_{1b} and H_{1c}. Likewise, absorptive capacity also has a positive and significant relation with the exploitative innovation competencies (β= 0.576, p < 0.001) and with the exploratory innovation competencies (β= 0.594, p < 0.001). Thus, these results support hypotheses H_{1d} and H_{1e}.

Hypothesis H_{2a} postulates a positive effect of a responsive market orientation on the exploitation innovation competencies. This hypothesis has support because (β= 0.230, p< 0.001). Similarly, hypothesis H_{2b} postulates a positive effect of a proactive market orientation on the exploratory innovation competencies. This hypothesis was not supported.

Finally, hypotheses H_{3a} and H_{3b} postulate that the exploitative innovation competencies and the exploratory innovation competencies positively relate to manufacturing flexibility. The results show that only H_{3a} has support because (β= 0.321, p< 0.01).

4.4. Mediation hypotheses

A construct can be explained by indirect effects as well as by direct effects (Little *et al*., 2007). The existence of a significant indirect effect in a chain of causation indicates that mediation is present (Zhao *et al*., 2010). In this sense, a hypothesized mediator is an additional link in a certain chain of causation. Mediation renders testing hypotheses more consistent and precise

(Malhotra *et al*., 2014).

To test the indirect effects (H_{4a} and H_{4b}), we conduct a bootstrap analysis with 1,000 resamples and estimate the indirect effect within a 90% confidence interval. The standardized indirect effects obtained using the bias-corrected percentile method are presented in Table 3.

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Insert table 3 here

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The results show that the mediation hypothesis H_{4a} is supported with (β = 0.074, $p < 0.01$). Thus, we find that the relation between the responsive market orientation and manufacturing flexibility is mediated by the exploitative innovation competencies. Hypothesis H_{4b} postulates that the relation between the proactive market orientation and manufacturing flexibility is mediated by the exploratory innovation competencies. This standardized indirect effect is not significant because (β = - 0.005, NS). Thus, hypotheses H_{4b} is not supported.

5. DISCUSSION

The main purpose of this study was to evaluate how exploitation and exploration innovation strategies separately affect manufacturing flexibility and, in addition, to investigate the mediating role of such strategies in the relation between responsive and proactive market orientations and manufacturing flexibility.

The findings show that firms seem to enhance manufacturing flexibility through absorptive capacity and a combination of a responsive market orientation and their exploitative innovation competencies (innovation reliability strategy). These findings align with the research (Patel *et al.*, 2012; Tamayo-Torres, *et al*. (2017). Thus, this combination positively affects manufacturing flexibility, while the combination of a proactive market orientation and exploratory innovation competencies provides no significant effect on it whatsoever. Furthermore, both the effects of absorptive capacity and the exploitative innovation competencies on manufacturing flexibility

are strong. Like Patel *et al*. (2012), our results show that the exploitative innovation competencies affect manufacturing flexibility as a complement to absorptive capacity. Since the exploitative innovation competencies are strongly expressed by the optimization of firm-specific knowledge and the competencies related to familiar products and technologies, its significantly positive effect on manufacturing flexibility means that it is the incremental optimization of innovation competencies that affects manufacturing flexibility. This optimization is a continuous process in which a communication between the innovation reliability strategy and the operations of the firm is in place.

As the findings show, the direct effect of exploratory innovation competencies on manufacturing flexibility is not significant. An explanation for this finding could relate to the incompatibility of short-term efficiency with long-term adaptability, also known as the productivity dilemma (Abernathy, 1978). Since theoretical evidence exists to support the expected significance of such relation, the result may be due to the time period to which the measure of innovation competencies is associated and its relative short term (five years). Therefore, further research would gain to include longer-term related measures (Brion *et al*., 2010). This suggestion is congruent with other studies implications, such as those observing that organizational evolution integrates periods of discontinuous change (Tushman and O'Reilly, 1996) or, more precisely, that organizational evolution is a process with long periods of steady progress, mostly reliant on exploitation and alignment, with some infrequent phases of radical changes dominated by exploration (Tushman and O'Reilly, 1996). Overall, long-term success seems to require a balance between continuity and change (Raish and Birkinshaw, 2008). It is possible then that exploratory innovation competencies can only be expected to exert significant impact on manufacturing flexibility on the rare moments in which firms need to more radically overhaul themselves, changing their own perspective of manufacturing flexibility (Atuahene-Gima, 2005). For example, when firms need to adopt technologies with the power to disrupt and completely change their own initial concepts of flexibility. One of the reasons this is rare is because it is costly: capital-intensive plants and equipment are not easily interchangeable or

renovated (Miller and Cardinal, 1994) without extensive investments in time, money, knowledge and other resources. Consequently, plants and equipment are prone to less frequent extensive and exploratory overhaul. Lastly, the study collects information from different manufacturing sectors, unlikely to radically change at the same time period in which the measure was taken.

However, an increased risk of obsolescence exists for organizations that rely mostly on exploitation (Levinthal and March, 1993). In such organizations, core rigidities can emerge due to narrower searches and more rigid and limitative contextual cognitive maps (Leonard-Barton, 1992). While such a pattern can facilitate short-term gains, it may also end up in competence traps and poor adaptive response to wider and deeper changes in the environment (Ahuja and Lampert, 2001).

Our results extend the knowledge on exploration and exploitation by showing that a mediation role exists for exploitative innovation competencies in the relation between a responsive market orientation and manufacturing flexibility. The non-significance of any indirect effects between absorptive capacity and manufacturing flexibility through a proactive market orientation and exploratory innovation competencies means that the indirect effects flow through exploitative innovation competencies. However, this finding also means that firms are not being proactive towards their customers nor seeking to effectively convert their latent needs into leads to explore their innovation competence. This is consistent with the need for long-term innovation practices, as suggested by Brion *et al*. (2010). Andriopoulos and Lewis (2009) highlight the existence of several innovation paradoxes such as strategic intent, customer orientation, and personal drivers. Furthermore, the organizational context can be an important antecedent that influences the firm's ability to integrate knowledge resources in their innovation processes (Martini *et al*., 2015). This antecedent offers an additional explanation for the lack of effect of exploratory innovation competencies on manufacturing flexibility while it indicates the existence of a serious managerial shortcoming: firms do not seem to be properly engaged nor effective at developing their innovation variability strategy.

The antecedent role of absorptive capacity to manufacturing flexibility is confirmed in this study as well as its antecedence to exploitative and exploratory innovation competencies and its priority in such antecedence *versus* market orientation (Patel *et al*., 2012).

Overall, the findings show the firm's tendency to develop manufacturing flexibility more through the reliability associated with optimizing its innovation routines and processes than through the variability associated with riskier innovation strategies. These findings may have alternative explanations and raise more questions for future research. First, this study's findings partly diverge from previous studies that have confirmed the positive effect of ambidexterity on manufacturing flexibility, since only the exploitative innovation competencies seems to command such an effect. The question is to better define the boundaries and circumstances explaining the different findings. Second, firms are enhancing business performance through higher exploratory innovation competencies, despite it not having a significant effect on manufacturing flexibility. This fact raises the question of whether there could be a lag between the improvement of business performance and manufacturing flexibility. Could the enhancement of the first predict further developments in the latter? Fourth, the possibility that many of the firms in the sample were affected by credit restrictions may justify the lack of a meaningful effect of exploratory innovation competencies on manufacturing flexibility, since this competencies tends to require comparatively more intense financial resources. Could this requirement be a central explanation or are the findings revealing a more pervasive pattern?

These findings contain important lessons as expressed by Mishra, et al. (2014) concerning the importance of firm-specific organizational absorptive capacity to the development of manufacturing flexibility, and the higher relative importance of absorptive capacity to the development of innovation competencies, when compared to market orientation. This combination contains a surprising insight to managers as it elevates absorptive capacity to a priority status in relation to market orientation. It does not suggest that market orientation is detrimental but, perhaps, that (i) manufacturing firms are not being as effective as they should

be in using market orientation to foster innovation competences or (ii) that firms have achieved a state of competition - stable market preferences - in which the contributions coming from customers' needs may no longer be as important in differentiating the offerings of manufacturing firms, something that is the primary role of innovation and seems less bounded than the explicit or implicit confines of the customers' mindsets. A remaining question lingers for the future: is this emerging priority structural or is it the result of a defective marketing and innovation culture in manufacturing firms, namely in what concerns their proactive market orientation and exploratory innovation competencies?

6. CONCLUSIONS

6.1. Theoretical implications

This study expands on Tu *et al*. (2006) and especially on Patel *et al*. (2012) by finding that absorptive capacity and an innovation reliability strategy are key manufacturing flexibility antecedents. The study of Tu *et al*. (2006) uses time-based manufacturing practices as the dependent variable, while the study of Patel *et al*. (2012) considers absorptive capacity and ambidexterity (without separating between exploitation and exploration) as moderators of the relations between environmental uncertainty, manufacturing flexibility, and firm performance.

The current study is, to our knowledge, the first to offer empirical evidence of the links between absorptive capacity and exploitation and exploration innovation competencies separately with manufacturing flexibility. This study contributes to the operations management literature by offering a further probe into the links between the strategic and the operations perspectives that follows the call of Ketchen and Giunipero (2004) and advances the research on the information-processing antecedents of manufacturing flexibility (Ojha *et al*., 2015). Furthermore, the study adds empirical evidence of a multidimensional concept of manufacturing flexibility, which is in line with its latest operationalization (Pérez Pérez *et al*., 2016; Rogers *et*

al., 2011; Zhang *et al*., 2003).

This study also contributes to the literature of ambidexterity and innovation by (i) separately studying the direct effects of exploitative and exploratory innovation competencies on manufacturing flexibility, (ii) probing the mediating roles of such strategies in the relation between absorptive capacity and manufacturing flexibility, (iii) adding further rationale and evidence on the less examined link between absorptive capacity and incremental innovation (Lane *et al*., 2006), and (iv) responding to the calls of Adler *et al*. (2009) and Andriopoulos and Lewis (2009) to explore ambidexterity in an operations context.

As the findings illustrate, absorptive capacity is shown to simultaneously enhance the innovation reliability (or innovation exploitation) and variability (or innovation exploration) strategies. This suggests absorptive capacity as an antecedent of ambidexterity, but also as part of it. Instead of the more usual but abstract interaction between innovation exploitation and exploration typically used in the conceptualization of ambidexterity, this study looks at absorptive capacity as the mechanism that interrelates the complementary learning that exploitation and exploration involve.

Absorptive capacity amplifies the flexibility of the firm's response to demand, competitive and technological uncertainty, through a more effective analysis and interpretation of environmental changes and a more consequent acquisition, sharing and use of knowledge to approach the realignment and renewal of operational capabilities (Patel et al., 2012). This capability scope is large, potentially encompassing knowledge about new technologies as much as about market trends and business models and even about organizational trends. The large scope of absorptive capacity is what makes it a useful tool in shaping other core capabilities, such as innovation flexibility (innovation reliability and variability strategies) as well as manufacturing flexibility.

6.2. Practical implications

Managerial implications can also be deduced. First, managers should foster their firm's

absorptive capacity in order to also develop manufacturing flexibility. This encouragement requires setting a culture for open learning as well as providing incentives to qualified employees and teams to seek, acquire, share, and use external knowledge with a wide utility scope that is useful for innovation competencies and manufacturing flexibility.

Second, managers should develop and use exploitative innovation competencies in close relation with incremental optimizations of manufacturing flexibility, while also fostering the later through absorptive capacity. Such a policy would easily amplify the development of manufacturing flexibility through exploitative innovation competencies.

Third, firms represented by the sample seem to ineffectively use a proactive market orientation. The reasons for this lack of effectiveness could be either cultural or related to the prevalent industry sectors in the sample, many of which are traditional. However, the finding indicates that the potential for a better use of the innovation variability strategy exists by seeking a better understanding of the customers' latent needs while aligning a proactive market orientation with exploratory innovation competencies. Managers should not overlook their overall innovation variability strategy and its expected medium to long-term positive effects on manufacturing flexibility. Without such a concern, innovation flexibility could remain hampered and stuck on an over-exploitation gear with future negative consequences for the development of manufacturing flexibility.

6.3. Limitations and future research

While the findings show that the simultaneous use of reliability and variability innovation strategies is associated with higher manufacturing flexibility, it would be enriching to perform similar studies in specific activity sectors or different environmental conditions, analyzing the confounding effects (c.f. Pinheiro et al., 2020; Vokurka & O'Leary-Kelly, 2000). Additionally, studies performed under survivability-threatening conditions would be worth pursuing to search for the limiting conditions that could cause an innovation variability strategy to become temporarily predominant. The expansion of this research into different time moments and contrasting management cultures, namely gathering data from different countries, could also

help clarify the circumstances under which firms would engage in riskier innovation activities of a more exploratory nature. Furthermore, cross-sectional studies have limitations in supporting the causality proposed in the hypotheses. Additionally, single informant studies are more prone to common variance issues, while the exclusive use of subjective measures is subject to respondent bias and social desirability issues. Future research on the topic would benefit from multiple informant data and secondary objective data (e.g., investments in R&D and operations performance indicators) to limit common variance issues.

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