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INNOVATION RELIABILITY AND VARIABILITY STRATEGIES IN THE RELATION BETWEEN ABSORPTIVE CAPACITY AND MANUFACTURING FLEXIBILITY

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Abstract

INNOVATION RELIABILITY AND VARIABILITY STRATEGIES IN THE RELATION BETWEEN ABSORPTIVE CAPACITY AND MANUFACTURING FLEXIBILITY José M. Pinheiro, School of Economics of the University of Coimbra and Renova SA Enrolment / Expected final date: 2013 – 2018, Email: jose.pinheiro@renova.pt State of the Art New measures have been developing to capture the multidimensional character of manufacturing flexibility (Rogers, et al., 2011). Due to ever shorter product cycles, firms require increasing levels of manufacturing flexibility, one of the multi-dimensions firms use to engage in a growing global competition. It holds high strategic relevance, being even regarded as a reactive and proactive strategic capability (Brettel, et al., 2016). Does strategic flexibility, viewed as dual, exploitative and explorative, market and innovation

competence orientations, helps steer and develop manufacturing flexibility beyond the direct role of absorptive capacity? While the literature usually separates these constructs, a unified perspective of how they work together is presented as a contribution. Research Gap Although authors such as Tu et al. (2006) and Patel et al. (2012) have established absorptive capacity's positive impact on manufacturing flexibility, the role of exploitative and explorative orientations in such relation is up for discussion. But that investigation is important: such behaviors express strategic flexibility, making it relevant to probe their role in connection with manufacturing flexibility, responsible for the firm's response in terms of operational performance. At the base of exploitation activities is the creation of reliability in the existing firm's experience, while at the base of exploration activities, is the creation of variability in such experience (Mom, et al., 2007). Is the combination of innovation reliability and variability strategies crucial to the synergy between strategic flexibility and manufacturing flexibility? Theoretical Arguments Absorptive capacity positively affects manufacturing flexibility by enabling firms to more effectively analyze and interpret information of changes concerning the operational environment, allowing then better reconfiguration, realignment, and renewal of operational capabilities (Patel, et al., 2012). Van den Bosch et al. (1999) support absorptive capacity fosters incremental innovation through deeper understanding of a narrow range of closely related topics, while Lane et al. (2006) observe that the relationship between absorptive capacity and radical innovation has received little attention, but that absorptive capacity components focusing non-narrow knowledge domains could help fuel radical innovation. Since the firm's innovation reliability experience is strongly reflected by optimizations of specific, firm-related, knowledge on familiar products, market approaches, and technologies, its resulting incremental changes could relate also to incremental modifications in manufacturing flexibility. On the other hand, the firm's innovation variability experience, promoting more dramatic changes, could exert different pressure while prompting manufacturing flexibility changes to respond accordingly. Method To tackle the research question an integrated theoretical model was developed, linking absorptive capacity (knowledge acquisition, sharing, and creation) to market orientation (reactive-proactive view), innovation competence orientation (exploitation-exploration), and manufacturing flexibility (supply chain, labor, equipment, routing, volume, and product flexibilities). 3728 Portuguese manufacturing firms with 20+ employees were surveyed, covering 60%-62% of the population (PORDATA, 2016). The scales used were grounded in the literature. Of the 515 responses received, 370 were complete and validated (10%), covering 6.5% of the population. The validated responses sample is unbiased and large enough to enable inference. A two-level model development was adopted. Firstly, the reliability, convergent validity, and discriminant validity of the constructs in the measurement model were evaluated. Common method variance was assessed. Secondly, the structural model fit was evaluated (

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ABSTRACT

Shifting demand and ever shorter product cycles increasing the levels of manufacturing flexibility required to address growing global competition. Although the literature has established absorptive capacity's positive impact on manufacturing flexibility, the role of exploitative and explorative innovation orientations in such relation is up for discussion. Investigating it is important: does strategic flexibility, viewed in terms of exploitative and explorative firm behaviors, help steer and develop manufacturing flexibility? An integrated theoretical model is developed, linking absorptive capacity to market orientation, innovation competence orientation, and manufacturing flexibility. A survey's data addressing top management is analyzed through SEM. While using a sample of 370 manufacturing firms, findings reveal that although absorptive capacity effects on manufacturing flexibility are mainly direct, a significant important positive indirect effect exists, flowing mainly through reactive market orientation and innovation competence exploitation: the exploitative behavior, innovation reliability strategy, predominates. Findings suggest that while absorptive capacity helps develop exploitative and explorative innovation strategies evenly, innovation competence exploration could be a strategic reserve to see action during the rarer occasions when firms need to reinvent themselves, more deeply overhauling manufacturing flexibility.

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

INTRODUCTION

Collis (1994) defended that organizational capabilities could be articulated with the resource-based view of the firm, to be seen as a source of sustainable competitive advantage. He pointed out that the action of time could render such competitive advantage a temporary attribute, however, given such capabilities possible erosion and replacement, or obsolescence, through the emergence of higher-order capabilities of the "learning to learn" kind. Similarly, Grant (1996) developed a knowledge-based theory of organizational capability, focusing the processes involved in the integration of knowledge toward creating capabilities, identified as critical for firms to respond and adapt to hypercompetitive markets. While a capability generally designates a certain functional area of the firm enabling it to engage specific actions, a competence refers to the knowledge, skills, and resources, shaping the firm's ability to deliver superior customer value (Day, 1994). In other words a competence designates the proficiency through which a capability is put to practice. Both Collis and Grant's visions come close to what would later emerge as the dynamic capabilities perspective, which has identified a class of capabilities to integrate, build, and reconfigure, internal and external competences able to address rapidly changing environments (Teece, Pisano, & Shuen, 1997). Such capabilities have been more recently defined as the abilities to reconfigure the firm's resources and routines in a manner envisioned by management (Zahra, Sapienza, & Davidsson, 2006). Such a framework represents an important contribution not only to strategic management, but also to economic theory, which still theoretically confines management and the figure of the strategic manager to the agent's perspective (Helfat et al., 2009). Zahra and George (2002) have summarized what dynamic capabilities need to involve to be called as such: experience accumulation, knowledge articulation, and knowledge codification processes. The general perspective of learning as a capability building process closely relates to the more specific concept of absorptive capacity, the firm's ability to identify, assimilate, and explore knowledge gained from external sources, as defined by Cohen and Levinthal (1989). Such a capacity represents a background structure enabling the firm to exploit and explore acquired, transformed, and newly created knowledge (Cohen & Levinthal, 1994). In order to exploit externally acquired knowledge, firms need to translate it into usable forms oriented to the market, in their goal to build competitive advantage through innovation and strategic flexibility (Zahra & George, 2002). Market orientation, which is of interest to this study, is a capability that aims to align the firm with the market (Frishammar & Åke Hörte, 2007). It also reflects the characteristics of a dynamic capability, according to Zahra (2008). Market orientation requires the systematic use of generated knowledge to guide

strategy recognition, understanding, creation, selection, implementation, and modification toward adaptation, and response formulation, to international markets (Hunt & Morgan, 1997). Market orientation relates with recognizing current market conditions, as well as with predicting future market conditions (Kohli & Jaworski, 1990; Day, 1994; Slater & Narver, 1994). This ability of gathering and using information about the present and the future is what enables market orientation to relate with, and enhance, exploitative as well as explorative innovation (Fang et al., 2012). Because innovation related ambidexterity has been proven important to firm outcomes (Gibson & Birkinshaw, 2004), innovation competence orientation (exploitative and explorative) is of interest to this study, given it can be responsible for enhancing the competences required to develop the firm's products and innovation processes, in line with the demands of its environment and orientations of the firm's strategic management. Finally, the recognition of manufacturing flexibility as a dynamic capability has been made by Malik and Kotabe (2009): the importance of manufacturing flexibility relates to its impact on firm performance in a dynamic world. Anand and Ward (2004) have provided statistical evidence pointing to the fact that flexibility is a strong antecedent of performance, especially under higher turbulence environments. Finally, Wu (2006) has empirically concluded that resources affect performance rather indirectly through dynamic capabilities, such as innovation and market response speed, but also though operational capabilities such as manufacturing efficiency and flexibility.

This study uses a resource based view perspective to probe the interactions between absorptive capacity (knowledge acquisition, sharing, and creation), market orientation (reactive and proactive), innovation competence orientation (exploitation and exploration), and manufacturing flexibility. The mediating role that innovation competence orientation (exploitation and exploration) play in the relationships between market orientation (reactive and proactive) and manufacturing flexibility is also examined, as well as the varying intensity of such relations for different firm size groups. The study of such mediation is important to understand in detail how manufacturing firms transform absorptive capacity and use different market and innovation competences to develop manufacturing flexibility. The broader question however, seeks to understand how does strategic flexibility, viewed in terms of exploitative and explorative firm behaviors, help steer and develop manufacturing flexibility. The research question relates with the future avenues for research identified by Raisch et al. (2009), pp. 693, *(1) "What are the differences between situations in which managers address e*xploitation and exploration simultaneously and those situations in which they alternate between the two

tasks?", and (2) "Does the external search for new knowledge dominate in early stages while internal processes take the lead in later stages of [firm] d*evelopment?",* and goes beyond it in the attempt to clarify and establish the inner connections between strategic flexibility and manufacturing flexibility. The problem is relevant to practitioners: assessing if the manufacturing flexibility of their firm is limited by a relatively inferior learning from external sources, or by a limitation to assimilate such learning and use it on internal market and innovation competences, managers will be further aware of specific changes required to increase the firm's manufacturing flexibility. To tackle the research question a single resource based model integrating absorptive capacity, reactive and proactive market orientations, innovation competence exploitation and exploration, and manufacturing flexibility, was developed. While the literature usually separates these constructs, a unified perspective of how they work together is presented as a main contribution. The study of mediation effects and the influence of firm size are particularly important to understand how the firm's use of absorptive capacity on innovation competences can generate higher manufacturing flexibility levels. Further contributions of this study include better understanding of how absorptive capacity links to exploratory orientations, a relation Lane, Koka, and Pathak (2006) identified as relevant, yet rarely examined. The study uses structural equation modelling (SEM) to process the data and test the theoretical model developed. While the sample is large enough for the use of such method, the technique is also robust enough to simultaneously test the several hypotheses underlying the fairly complex theory hereby developed. The next section contains the theoretical background essentials for the hypotheses. The methods section describes data collection, the sample, and the validation of measurement instruments. The results section presents the main hypotheses tests, mediation, and multi-group moderation results for firm size. The last section, discussion, infers the results implications for management, and identifies limitations and issues for further research.

THEORY

Absorptive Capacity and Manufacturing Flexibility

According to Patel, Terjesen, and Li (2012), absorptive capacity is a learning capability that can explain differential firm behavior. Specifically, and in consideration to its relation with manufacturing flexibility, these authors defend that the role of absorptive capacity is to amplify the flexibility of the firm's response to demand, competitive and technological uncertainty, by enabling the firm to more effectively analyze and interpret information of changes concerning

the operational environment and thus more effectively approach reconfiguration, realignment, and renewal of operational capabilities. Firms with higher levels of absorptive capacity are expected to increase the scope and mobility of components of manufacturing flexibility, as well as more rapidly address their product mix, tending towards a higher effectiveness in processing demand information changes, to proactively respond to competitive landscape changes (Cohen & Levinthal, 1989), and better respond to technological innovations (Cohen & Levinthal, 1994; Narasimhan, Rajiv, & Dutta, 2006). Firms with lower levels of absorptive capacity are expected to respond less effectively to environmental changes, and less effectively use knowledge to manage manufacturing flexibility (Patel, Terjesen, & Li, 2012). As Rosenbloom and Christensen (1994) noted, breaking up internal inertia in firms involves anticipating the obsolescence of existing capabilities and creating new ones more aligned with newer technological standards. Camuffo and Volpato (1996), in a case study focusing the connection between Fiat's dynamic capabilities and operations, observed that the implementation and development of automation techniques were a path-dependent, non-linear, learning process. They argued that the technologies used by Fiat resulted from a wide diversity of sources such as learning, internal developments, external acquisitions, imitation of competitors, replication, and selection of capabilities. Without knowledge-capabilities, such as absorptive capacity, technological changes and its implications cannot be fully understood and therefore firms will become limited in the development of adequate levels and types of manufacturing flexibility. Knowledge levels have been associated before with manufacturing flexibility: Braglia and Petroni (2000), who examined such a relation for medium-sized manufacturing firms, found that firms behave in firm-specific and situation-specific manner when combining resources and capabilities required to address their environment. In such a combinatorial process, they have identified as keys the maturity of managerial competence and organizational development. Koh and Gunasekaran (2006) have suggested that manufacturing firms should use tacit as well as explicit knowledge in their management and approach to uncertainty, in order to more adequately integrate materials and enterprise resource planning systems. Empirical evidence is available supporting the impact of absorptive capacity on the capability to implement new manufacturing practices, and the identification of process innovations (Tu et al., 2006). Empirical support for the link between absorptive capacity and the firm's collaboration with supply chain partners also exists (Zacharia et al., 2011), the same applying to the link between absorptive capacity and the firm's integration of supply chain technology (Autry et al., 2010). Absorptive capacity's higher levels in firms have also been observed to be associated with higher employee and cross-functional interactions (Jansen, Van Den Bosch, & Volberda, 2005;

Todorova & Durisin, 2007), necessary for the exchanges leading to better organizational learning. There seems to be enough theroretical and empirical grounds for this study to hypothesize H1a: Absorptive capacity is positively associated with manufacturing flexibility.

Absorptive Capacity and Market and Innovation Competences Orientations

Learning evolves from an individual or small group level, to a more advanced organizational learning, emerging in such a process as a dynamic capability (Brockman, 2013). Absorptive capacity, a specific form of learning (Sun & Anderson, 2010), expresses the firm's ability to identify, assimilate, and explore knowledge gained from external sources, as first defined by Cohen and Levinthal (1989), who implicitly presented it as a capability by the use of the term "ability" (Lane, Koka, & Pathak, 2006). Subsequently, Cohen and Levinthal (1990) developed the definition, as the firm's ability to value, assimilate, and commercially use new external knowledge. The intent of producing commercial applications out of absorptive capacity establishes its interest to the development of marketing related processes, and thus also of market orientation, at its core. In order to benefit from externally acquired knowledge, firms need to translate it into market-oriented usable forms, building competitive advantage through innovation and strategic flexibility (Zahra & George, 2002). The view of absorptive capacity taken in this study combines and simplifies the definitions of Cohen & Levinthal (1990), Cohen & Levinthal (1994), and Zahra & George (2002), reducing its dimensions to the very essential. More specifically, it conceptualizes absorptive capacity as a three dimensional dynamic capability: (1) knowledge acquisition, the organizational practice of identifying, valuing, and acquiring new knowledge about the market, technologies, trends, and business models; (2) knowledge sharing, the organizational practice of assimilating, adapting, codifying, and disseminating such knowledge within the organization; and (3) knowledge creation, the organizational practice of combining externally acquired knowledge with existing knowledge, to create new knowledge. Learning via the acquisition of knowledge is a central factor for both exploitative and explorative related activities internal to firms (Mom, Van Den Bosch, & Volberda, 2007). As to market orientation, also a dynamic capability (Zahra, 2008), its purpose is that of achieving an external alignment: that of the firm with its competitive landscape and environmental dynamism. It is defined by the firm's ability to follow and respond to changes in the marketplace while using intelligence generation and information dissemination (Zahra, 2008). That is about engaging with customers to deliver accordingly to their perceived needs in the present and the future (He & Wei, 2011). It requires the systematic use of generated knowledge (also through absorptive capacity) to guide strategy recognition, understanding,

creation, selection, implementation, and modification toward adaptation and response formulation (Hunt & Morgan, 1996). This study adopts the market orientation concept of Narver, Slater, and MacLachlan (2004), presenting it as a dual set of behaviors: reactive market orientation, the firm's process aiming to discover, understand, and satisfy, expressed customer's needs, and proactive market orientation, consisting in the firm's process to discover, understand, and satisfy, latent customer's needs. Separating both these components, which configure two different behaviors within the market orientation construct, is fundamental when also focusing innovation (Narver, Slater, & MacLachlan, 2004), precisely the case of this study. The related hypotheses laid out are H1b: Absorptive capacity is positively associated with reactive market orientation; and H1c: Absorptive capacity is positively associated with proactive market orientation.

To Cohen and Levinthal (1994) higher absorptive capacity enables firms to forecast trends and take advantage of opportunities earlier on than its competitors. This fundaments its interest to the development of innovation processes. Absorptive capacity has been shown to influence innovation before (Tsai, 2001). In fact, Lane, Koka, and Pathak (2006), having examined 289 papers between 1991 and 2002, also noted that innovation was the only topic focused by the utilization dimension of absorptive capacity. Anderson & Tushman (1990) and Helfat (1997), support that absorptive capacity increases the speed and frequency of incremental innovation based on the argument that incremental innovation develops primarily upon a base of existing knowledge. Similarly, Van Den Bosch, Volberda, and De Boer (1999) support that absorptive capacity fosters incremental innovation through deeper understanding of a narrow range of closely related topics. By contrast, Lane, Koka, and Pathak (2006) observed that the relationship between current 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, Volberda, & De Boer, 1999). Absorptive capacity components focusing non-narrow knowledge domains could help fuel radical innovation (Lane, Koka, & Pathak, 2006). In this study, the relations between absorptive capacity and two underlying behaviors of innovation processes, or strategies, are probed for: innovation competence exploitation and innovation competence exploration. Innovation competence exploitation, in this study, expresses incremental refinements of the firm's existing innovation knowledge, skills, and processes, while innovation competence exploration expresses more substantive overhauls of such knowledge, skills, and processes, therefore adopting the same concept of innovation competence orientations as Atuahene-Gima's (2005). This study

hypothesizes that H1d: Absorptive capacity is positively associated with innovation competence exploitation; and H1e: Absorptive capacity is positively associated with innovation competence exploration.

Market and Innovation Competence Orientations and Manufacturing Flexibility

The goal of the market orientation capability is that of achieving an external alignment. In fact, market orientation aim is to align the firm with the market (Frishammar & Âke Hörte, 2007). Defined by the firm's ability to follow and respond to changes in the marketplace, market orientation is a market-driven capability (Jaworski & Kohli, 1993; Slater & Narver, 1999; Im, Hussain, & Sengupta, 2008; Zahra, 2008). Market orientation is supposed to allow better market-oriented firms to develop and offer adapted solutions and products to the markets in a more efficient manner that in less market-oriented firms. This is achieved through a process of engaging and listening to customers in order to deliver accordingly to their perceived needs in the present and the future (He & Wei, 2011). Theoretically, market orientation contributes to innovation through gathering market intelligence while allowing the firm to make an appropriate use of it (Fang et al., 2012). Innovation is about the future offer of firms in differentiated and novel ways. It involves knowing stuff about future needs. Market orientation concerns not only learning about present day markets and customer's needs, but also anticipating markets future conditions (Kohli & Jaworski, 1990; Day, 1994; Slater & Narver, 1994). This ability of gathering and using information about the present and the future is what makes market orientation to relate to, and enhance, exploitative, as well as explorative, forms of innovation (Fang et al., 2012). Significant influence of market orientation over innovation characteristics and performance has been empirically presented in the literature, in studies focusing services as well as manufacturing firms (Atuahene-Gima, 1996). Specifically, Atuahene-Gima (1996) discovered a positive and significant association between market orientation (customer-competitor view), 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. Market orientation (customer-competitor view) has been 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). Using a sample of Chinese firms, 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 exploitative and explorative capabilities were in turn

associated with incremental and radical new product innovation outcomes. There is further strong empirical evidence of the positive impact of market orientation on new product success: reporting on empirical studies published between 1990 and 2003, published in 55 marketing journals, Baker and Sinkula (2005) have concluded that empirical support for the positive impact of market orientation on new product success was transversal to the batch of papers under their analysis. In a study based on a sample of small and medium sized UK firms, empirical findings have shown the association of market orientation and innovation (Laforet, 2008). In such case, results suggest that non-high tech firms fare better when displaying a proactive market orientation. Another study, involving a sample of Taiwanese high technology firms, found that responsive and proactive market orientation allow for the development of exploitative and explorative innovation, respectively (Li, Lin, & Chu, 2008). The authors have reported a positive significant effect of responsive market orientation on incremental innovations and a positive significant effect of proactive market orientation on radical innovations. This approach improved the understanding of how reactive and proactive modes of market orientation can affect incremental and radical innovation (to which exploitative and explorative innovation competences are required) and enable the contextual ambidexterity of innovation in firms: the simultaneous pursuit of exploitative and explorative innovation practices within firms. Recent findings based on a sample of manufacturing firms from Taiwan have corroborated the positive effect of market orientation on exploitation and exploration innovation activities (Fang et al., 2012). This study hypothesizes that H2a: Reactive market orientation is positively associated with innovation competence exploitation; and H2b: Proactive market orientation is positively associated with innovation competence exploration.

Innovation Competence Orientation and Manufacturing Flexibility

While absorptive capacity essentially acquires, assimilates (shares), and creates knowledge, different innovation competences (exploitative and explorative) help the firm figuring out how to use such knowledge, using the information made available by different market orientation types (reactive and proactive) for exploitative and explorative purposes. Growing competitiveness and dynamic environments, international markets globalization, and the development of new technologies, also require managers to think of, implement, and develop dynamic production systems (Narasimhan & Das, 1999). Manufacturing flexibility enables adaptation, and even anticipation, to environmental changes, offering manufacturing firms relative competitive advantages (Beach et al., 2000). Rogers, Ojha, and White (2011), who have proposed a multi-dimensional scale for manufacturing flexibility, illustrate the need for the

complementarity of its six dimensions (product mix flexibility, routing flexibility, equipment flexibility, volume flexibility, labor flexibility, and supply management flexibility) with the example of divergent practices by General Motors and Toyota in the eighties. According to them, and in spite of heavy investments in advanced manufacturing technology, General Motors lines in the nineties were still much less flexible than Toyota's. While Toyota exploited the synergies across their supply management, human resource management, and operations (Milgrom & Roberts, 1995), General Motors did not, at least to the same extent as Toyota did. Relative competitive advantage require firms to develop new capabilities and competences required for the adaptation to the environment (Tamayo-Torres, Ruiz-Moreno, & Llórens-Montes, 2011). Lavie and Rosenkopf (2006) have stated that firms must explore new possibilities for adapting to future environmental changes, as well as exploiting existing capabilities, in order to compete in a dynamic market. Whereas exploitation is more associated to refinement and efficiency, exploration is more associated with variation, experimentation, and higher risk (March, 1991). While exploitation is implemented through activities that aim to establish standardized processes and can be associated to a short term perspective, exploration is more about creating new knowledge, and entirely new ways to solve problems, being more associated to 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, Li, & Usher, 2000). If strategic behavior aims at keeping production costs under control and reducing throughput times, while adequately responding to demand requisites variations, firms can either use exploitation of capabilities in the short term, and/or exploration of new ideas for the longer term (Miller, Zhao, & Calantone, 2006). Exploitation and exploration configure different strategic options for the firm to respond to competitors (Li, Lin, & Chu, 2008). One of the ways to implement exploitation is the elimination of deficient tasks and the search of new routes (Levinthal and March, 1993), while for the case of implementing exploration, a longer-term perspective is at play, in order to find alternatives to improve what exists (March, 1991). Innovation competences in manufacturing firms are bounded by what is possible to produce, how, how fast, at which cost, and with which quality. While also being a response tool to competitors, innovation competences operate through processes that must have in attention the specificities of their underlying production systems, and develop in line with available technical possibilities, either to produce incremental innovations bounded by demand and manufacturing flexibility requirements, or to propose more radical solutions based on available production systems and technology. Tamayo-Torres, Ruiz-Moreno, and Llórens-Montes (2011), focusing on Spanish manufacturing firms and

investigating the relation between manufacturing flexibility and knowledge ambidexterity, found that higher levels of exploitative and explorative forms of knowledge are associated with higher levels of manufacturing flexibility, such a relation being amplified under higher environmental turbulence conditions and higher organizational learning levels. This suggests that an association between innovation competence orientation (exploitative and explorative) and manufacturing flexibility has to be reckoned. Ambidexterity promotes flexibility in the firm's response to environmental changes affecting demand, to changes in the competitive landscape, and to technological changes as well (Patel, Terjesen, & Li, 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, Terjesen, & Li, 2012). Patel, Terjesen, and Li (2012), exploring the contingent role of operational absorptive capacity and operational ambidexterity in the operations environment, have found ambidexterity to affect firm performance through manufacturing flexibility. Finally, Singh and Khamba (2014), investigating the connections between organizational competences and increased business performance in supply chain management, have proposed and supported innovation competences as drivers for supply chain management capabilities (one of the dimensions of manufacturing flexibility). Considering this body of theoretical and empirical evidence this study hypothesizes that H3a: Innovation competence exploitation is positively related with manufacturing flexibility; and H3b: Innovation competence exploration is positively related with manufacturing flexibility. In addition, this study also proposes two mediation hypotheses, namely M1a: Innovation competence exploitation mediates the positive relationship between reactive market orientation and manufacturing flexibility; and M2a: Innovation competence exploration mediates the positive relationship between proactive market orientation and manufacturing flexibility. Figure 1 presents the model's main hypotheses.

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Figure 1

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METHODS

Data Collection, Sample, and Data Analysis

An online questionnaire was developed to measure, at the firm level, the constructs of interest for this study. The questionnaire was pre-tested for contents validity through a panel of four independent senior managers in two different manufacturing firms, and two management scholars. This process was used to fine tune the intelligibility of the questions and the clarity of the wording used, having resulted in minor wording changes. The survey targeted CEOs and CFOs as respondents, a decision taken after discussion between the scholars and the managers over the appropriate key respondents attending to the context of the survey and the nature of the questions themselves. The survey, guaranteeing the respondent's anonymity, was then launched by emailing all 3728 Portuguese manufacturing firms with 20+ employees registered in the Kompass International Neuenschwander SA database. The threshold for minimum firm size chosen (20+ employees) was selected in order to capture responses from small, medium, and large firms. Of the 3728 manufacturing firms, 2082 had between 20 and 49 employees (55.9%), 1403 had between 50 and 249 employees (37.6%), and 243 firms had 250 or more employees (6.5%). A total of 515 responses was obtained, with 370 responses validated after checking for missing data and non-engaged response profiles (10% net response rate within the sample). As per the more recent official data on the subject (PORDATA, 2016), this study's sample of respondents covered about 6.5% of the population (manufacturing firms in Portugal with 20 or more employees). To assess the impact of common method bias the Harman's one factor test was performed (Harman, 1967), as well as the unmeasured latent factor test (Podsakoff et al., 2003). Harman's one factor test indicated no major single factor emerging from the analysis of all items in the measurement model. The principal components analysis' non-rotated free solution produced 9 factors with eigenvalues greater than 1.0, cumulatively accounting for 69.6% of the total variance, with the first extracted factor accounting for 32.8% of the variance in the data. The common latent factor method evidenced a relatively feeble common variance. The introduction of the common latent factor did not greatly affect the majority of the items standardized loadings (maximum change of 0.18 in one indicator only). The average change of standardized coefficients before and after the introduction of the common latent factor was of 0.07, and the median change of 0.08. The estimated common variance, obtained by squaring the unstandardized common loadings of the common latent factor, is under 35%. A two-level development of the model was adopted. On a first phase, the reliability, convergent validity, and discriminant validity of the constructs in the measurement model were evaluated. On a second phase, the structural equations model fit was evaluated.

Measures

A seven-point Likert-type scale was used for all non-demographic variables in the survey (from 1…totally disagree to 7…totally agree). Absorptive capacity was measured hypothesizing a second order construct with three components: knowledge acquisition, knowledge sharing, and knowledge creation. Knowledge acquisition was measured using 3 items adopted from Jansen, Van Den Bosch, and Volberda (2006) and Jaworski and Kohli (1993), reflecting the ability for acquiring external knowledge to the firm. Knowledge sharing was measured through 3 items adopted from Jaworski and Kohli (1993) and Tippins and Sohi (2003), capturing the ability to share knowledge among employees and within the firm. Finally, knowledge creation was measured through 4 items taken from Pavlou and Sawy (2006), Prieto, Revilla, & Rodríguez-Prado (2009), and Flatten et al. (2011), reflecting the ability of the firm's employees to learn from external and internal knowledge to produce new ideas. Manufacturing flexibility was measured with the scale developed by Rogers, Ojha, and White (2011), viewing manufacturing flexibility as a second order construct with six dimensions measured through 3 items each: product-mix flexibility, routing flexibility, equipment flexibility (machines flexibility), volume flexibility, labor flexibility, and supply chain flexibility. Reactive and proactive market orientations were measured through items originally developed by Narver, Slater, and MacLachlan (2004), of which 3 items were used to measure reactive market orientation, and 3 items to measure proactive market orientation. These items capture the ability of the firm to observe and retain customer's expressed as well as latent needs. Innovation competence exploitation and exploration were measured through 8 items adopted from Atuahene-Gima's (2005), 4 of which to measure innovation competence exploitation and the other 4 to measure innovation competence exploration. These items reflect the exploitation and exploration of innovation competences over a period of 5 years, in order to assess consolidated practices. Appendix 1 shows the standard loadings and critical ratios of all indicators in the questionnaire.

RESULTS

Measurement Model

The total variance extracted was of 61.3% (maximum likelihood method with free factor extraction), with a goodness of fit of 2.55. The measurement model revealed composite reliabilities above 0.70 for all constructs (Hair et al., 2010), ranging from 0.84 (proactive market orientation) to 0.93 (innovation competence exploitation). The average variance extracted (AVE) was above 0.50 for all constructs (Hair et al., 2010), ranging from 0.51 (manufacturing flexibility) to 0.80 (absorptive capacity). This indicates that all constructs have convergent reliability. For all constructs, the average variance extracted (AVE) was greater than the

maximum shared variance (MSV), and also greater than the average shared variance (ASV). The square root of AVE was also greater than inter-construct correlations, for all variables. Thus, the measurement model constructs do not display discriminant convergence issues (Hair et al., 2010). Table 1 presents a summary of descriptive statistics characterizing the main constructs in the measurement model.

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Table 1

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The measurement model evidenced a reasonable model fit ($\chi^2 = 1502{,}9$, Chi/df=1.988, CFI=0.922, TLI=0,915, NFI=0.855, RMR=0.149, RMSEA=0.052). Configural invariance of the model for firm size was evaluated by looking at the joint model fit for groups of smaller and larger firm size (mean split, with 166 smaller firms and 204 larger firms; $\chi^2 = 2652{,}9$, Chi/df=1.755, CFI=0.885, TLI=0,876, NFI=0.771, RMR=0.177, RMSEA=0.045). Partial metric invariance was evaluated looking at the significance of the z-score for every indicator of each variable on the different groups under test (firm size). It was not found a significant z-score significance for the majority of indicators when comparing the different groups in each variable. In addition, a nested model analysis was used confirming partial metric invariance. This analysis was performed in order to enable multi-group moderation analysis on firm size.

Model Fit and Hypotheses Tests

Structural equation modelling (SEM) was used to test the main hypotheses. The model fit was fair ($\chi^2 = 1506{,}1$, Chi/df=1.98, CFI=0.922, TLI=0.915, NFI=0.855, RMR=0.131, RMSEA=0.052). The model explains 33% of the variance of manufacturing flexibility. Findings reveal statistical support for eight of the nine main hypotheses of the model, as well as statistical support for one of the two mediation hypotheses. Table 2 depicts the main hypotheses tests results and the model fit.

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Table 2

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Specifically, the path coefficient from absorptive capacity to manufacturing flexibility is significant at a level lower than 0.001 (β = 0.328; t = 3.485), thus supporting hypothesis H1a. The path going from absorptive capacity to reactive market orientation is significant at a level lower than 0.001 (β = 0.618; t = 10.008), thus supporting hypothesis H1b, while the path going from absorptive capacity to proactive market orientation is significant at a level lower than 0.001 (β = 0.608; t = 9.282), thus supporting hypothesis H1c. Hypothesis H1d is also corroborated to a statistical significance level below 0.001 (β = 0.231; t = 8.437), thus confirming the path going from absorptive capacity to innovation competence exploitation, while the path going from absorptive capacity to innovation competence exploration, hypothesis H1e, is also significant to a level lower than 0.001 (β = 0.581; t = 7.688). As to the impacts of market orientations (reactive and proactive) on innovation competences (exploitation and exploration), the path going from reactive market orientation to innovation competence exploitation is significant at a level lower than 0.001 (β = 0.231; t = 4.304), statistically supporting H2a, while the path going from proactive market orientation to innovation competence exploration is only significant at a level lower than 0.10 (β = 0.106; t = 1.693), statistically supporting H2b, albeit to a much lower degree. Finally, regarding the impacts of innovation competences (exploitation and exploration) on manufacturing flexibility, the path from innovation competence exploitation to manufacturing flexibility is significant at a level lower than 0.01 (β = 0.321; t = 3.086), thus supporting H3a, while the path going from innovation competence exploration to manufacturing flexibility shows no statistical significance, leaving H3b unsupported. To summarize, findings reveal empirical support for statistically significantly positive impacts of absorptive capacity on manufacturing flexibility (H1a), market orientations (reactive and proactive; H1b and H1c), and innovation competences (exploitation and exploration; H1d and H1e), as well as statistically significantly positive impacts of market orientations on innovation competences (H2a, H2b). Empirical support of positive impacts of innovation competences (exploitation and exploration) on manufacturing flexibility is only partial (H3a).

Mediation

Using a 1000 bootstrap samples with replacement process at a 90% confidence level, it is presented in Table 3 the direct, indirect, and total standardized effects involved in both mediation hypothesis (M1a, b). Results show that only one of the two mediation hypotheses (M1a) is supported with statistical significance. Findings also identify the joint partial mediation of market orientations and innovation competences in the positive relationship

between absorptive capacity and manufacturing flexibility, a direct result of the bootstrapping output from AMOS (not hypothesized a priori). Furthermore, since M1b is not supported and M1a exhibits week indirect effects, it is straightforward to conclude that the combined mediation of market orientation and innovation competence in the positive relationship between absorptive capacity and manufacturing flexibility occurs primarily through innovation competence exploitation.

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Table 3

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Composite paths significance through which the effects of absorptive capacity flow onto manufacturing flexibility can be estimated through the Sobel statistic (Mackinnon & Dwyer, 1993). The Sobel statistic for the effects flowing from absorptive capacity to manufacturing flexibility through innovation competence exploitation is of 2.89 (> 1.96), with a p-value of 0.0037, a significant indirect effect. Multiplying the standardized coefficients of the composite path we get the intensity of the effect: 0.182. On the other hand, the Sobel statistics for the effects from absorptive capacity flowing through innovation competence exploration is of -0.4326 (> -1.96), with a p-value of 0.66, a non-significant indirect effect. This means that all the indirect effects of absorptive capacity on manufacturing flexibility are flowing through innovation competence exploitation (0.182), and through reactive market orientation, to a much lesser extent (0.022), this later value resulting from the difference between the standardized coefficient of the totality of the indirect effects (0.204, see Table 3) and the standardized coefficient of the indirect effects flowing solely through innovation competence exploitation (0.182).

The moderation effect of firm size

The z-score on the differences of the model paths for smaller and larger firm groups were observed. Findings reveal the impact of absorptive capacity on innovation competence exploration is more intense in larger firms. On the other hand, results also show that, conversely, the impact of proactive market orientation on innovation competence exploration is more important in smaller size firms. The main results are expressed in Table 4.

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Table 4

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DISCUSSION AND IMPLICATIONS

Theoretical Contribution

Findings show that absorptive capacity is at least as important to explain exploitative behaviors as it is for explaining explorative behaviors, and manufacturing flexibility. This is the first study to articulate and integrate such a comprehensive set of relations. The study expands on Tu et al. (2006), as well as on Patel, Terjesen, and Li (2012), finding that absorptive capacity enhances manufacturing flexibility by confirming that firms with higher levels of absorptive capacity also present higher levels of manufacturing flexibility. Overall findings support Teece, Pisano, and Shuen (2007) theorizing market opportunities as drivers for the development of new products possibly involving the transformation of existing operational capabilities through learning, and also reflect Gupta and Govindarajan (2000), who have theorized the positive relation between learning and the intra-organizational transfers of knowledge, represented in our study by the links between absorptive capacity, market orientations, innovation competences orientations, and manufacturing flexibility. The study reinforces Gibson and Birkinshaw (2004) findings by confirming that market orientation (reactive-proactive view) impacts innovation competence orientation, and is in line with Li, Lin, and Chu (2008), who have specifically found that responsive and proactive market orientations allow the development of different innovation competences: exploitative and explorative orientations, respectively. Rather new to the literature of manufacturing flexibility, the findings show that firms with higher levels of innovation competence exploitation, and, to a lesser degree, reactive market orientation, present higher levels of manufacturing flexibility. Furthermore, the impact's intensity found for absorptive capacity and innovation competence exploitation on manufacturing flexibility are at the same level of importance. This finding suggests that innovation competence exploitation acts upon manufacturing flexibility in complementarity to absorptive capacity. Since innovation competence exploitation is strongly reflected by optimizations of specific, firm-related, knowledge and competences on familiar products and technologies, its significant positive impact on manufacturing flexibility suggests that incremental optimizations of innovation competence affect manufacturing flexibility, a possible expression of a continuous optimization process. On the other hand, a possible explanation for the lack of impact of innovation competence exploration on manufacturing flexibility can be rooted in the productivity dilemma

(Abernathy, 1978), describing an incompatibility between short-term efficiency and long-term adaptability. Since, theoretically, some grounding exists in support for positive impacts of innovation competence exploration on manufacturing flexibility, the fact that such hypothesis remains unconfirmed by this study only informs about such impact on the time frame of the measure of innovation competence exploration (five years), and not beyond. In future analysis considering longer term effects, such hypothesis should not be overlooked, given the rationale and grounding has been well established. Organizational adaptation theory defends that long-term success requires a balance between continuity and change (Raisch & Birkinshaw, 2008). Organizational evolution can be conceived as a process defined by long periods of steady evolution, marked by exploitation and alignment, and less frequent episodes of radical transformation, marked by exploration (Tushman & O'Reilley, 1996). It has also been thought to integrate periods of discontinuous change (Tushman & Romanelli, 1985). An explanation for the non-significance of the impact of innovation competence exploration on manufacturing flexibility can therefore be that the moment of observation has not coincided with one of more radical changes. Yet another consideration is that capital-intensive firms have capital assets, such as plants and equipment, which are not easily inter-changeable or renovated (Miller & Cardinal, 1994). Some inertia is to be expected in manufacturing firms for which equipment and machines represent a financially burdensome requisite. Such assets are therefore less permeable to an explorative innovation competence orientation. A third alternative explanation could be the non-effective use of innovation competence exploration toward the transformation of manufacturing flexibility. This would in practice mean that innovation competence exploration is at odds with manufacturing flexibility, except on the rare occasions that firms need to reinvent themselves, and decide to overhaul their technological roadmaps relative to manufacturing flexibility. Attention must be drawn to the risks that organizations more preponderantly engaged in exploitation may face, namely, the risk of obsolescence (Levinthal & March, 1993). Narrow searches leading to rigid, limited, cognitive maps and specialized competences can turn into core rigidities (Leonard-Barton, 1992). Preponderant engagement with exploitation, while improving short-term outcomes, may end up in competence traps and inadequate response to environmental changes (Ahuja & Lampert, 2001). As to firm size results suggest different mechanisms at play for developing innovation competence exploration: while in larger firms innovation competence exploration is mainly driven by absorptive capacity, in smaller firms, proactive market orientation plays an equally important role to that of absorptive capacity. There are at least two alternative and complementary explanations for such a finding: a) larger firms may be using more sophisticated absorptive capacity tools than smaller firms,

due to higher turnovers and also possibly more resources to incorporate knowledge and know-how from outside the firm; b) smaller firms, possibly with less resources to develop absorptive capacity, may be relying on their contact with the market to develop innovation competence exploration.

Management Implications

The main implications are: 1) managers should foster absorptive capacity in order to also develop manufacturing flexibility, 2) managers should develop and use innovation competence exploitation in close relation with (incremental) optimizations of manufacturing flexibility, and 3) smaller firm managers can rely on proactive market orientation to develop innovation competence exploration even if resources to develop absorptive capacity are not at hand.

Limitations and Directions for Future Research

This study involves cross-sectional, single informant data, and uses perceptual scales, with possible issues of causal reciprocity and common method bias. Future research on the topic would benefit from the use of longitudinal studies, multiple informant data, use of secondary data, and expansion of the research in time (data collection) and space (comparing firms in different to probe for cultural differences).

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TABLES

ABSCAP=absorptive capacity; REACT MKTOR=reactive market orientation; PROACT MKTOR=proactive market orientation; INNO C EXPLOIT=innovation competence exploitation; INNO C EXPLOR=innovation competence exploration; MANFLEX=manufacturing flexibility.

Table 1. Descriptive statistics for main constructs[1]

	SD	Y1	Y2	Y3	Y4	Y5	Y6	CR	AVE
ABSCAP (Y1)	0,92	**0,89**						0,92	0,80
MANFLEX (Y2)	0,77	0,52	**0,72**					0,86	0,51
REACT MKTOR (Y3)	1,11	0,61	0,38	**0,85**				0,89	0,73
PROACT MKTOR (Y4)	1,15	0,58	0,41	0,64	**0,80**			0,84	0,64
INNO C EXPLOIT (Y5)	0,97	0,70	0,53	0,60	0,59	**0,87**		0,93	0,76
INNO C EXPLOR (Y6)	1,21	0,63	0,41	0,49	0,50	0,76	**0,79**	0,87	0,62

[1]Diagonal entries are the square root of AVE; SD=Standard Deviation, CR=Composite Reliability; AVE=Average Variance Extracted; Correlations result from Measurement Model.

Table 2. Hypotheses tests[2], and structural model fit[3]

Hypothesis	**Path**	**Stand. Coef.**	**S.E.**	**C.R.**	**p**
H1a	ABSCAP → MANFLEX	0,328	0,079	3,485	***
H1b	ABSCAP → REACT MKTOR	0,618	0,075	10,008	***
H1c	ABSCAP → PROACT MKTOR	0,608	0,082	9,282	***
H1d	ABSCAP → INNO C EXPLOIT	0,231	0,071	8,437	***
H1e	ABSCAP → INNO C EXPLOR	0,581	0,099	7,688	***
H2a	REACT MKTOR → INNO C EXPLOIT	0,231	0,046	4,304	***
H2b	PROACT MKTOR → INNO C EXPLOR	0,106	0,066	1,693	*
H3a	INNO C EXPLOIT → MANFLEX	0,321	0,084	3,086	**
H3b	INNO C EXPLOR → MANFLEX	-0,041	0,060	-0,435	NS

[2]Two tailed; * p<0.10, ** p<0.01, *** p<0.001; NS=Not significant. [3]Model fit: $\chi^2 = 1506.1, df = 758; NFI = 0.855; TLI = 0.915; CFI = 0.922; RMSEA = 0.052.$

Table 3. Direct, indirect, and total standardized effects and significance[4] of mediators

Hyp.	**Mediators**	**Indirect Effect**	**Direct Effect**	**Total Effect**	**Med. Type**
M1a	INNO C EXPLOIT	0,074 (**)	-	0,074 (**)	-
M1b	INNO C EXPLOR	-0,004 (NS)	-	-0,004 (NS)	-
-	INNO C EXPLOIT + INNO C EXPLOR + REACT MKTOR + PROACT MKTOR	0,204 (**)	0,328 (**)	0,531 (**)	Partial

[4]Significance (in brackets) obtained with bias corrected percentile method (2-tailed); * p<0.10, ** p<0.01, *** p<0.001; NS=Not significant.

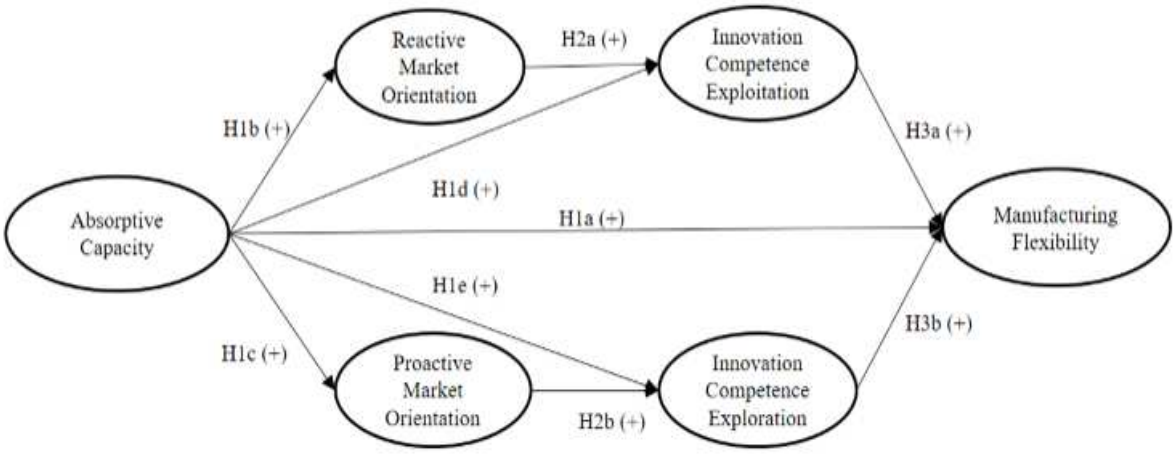
Table 4. Multi-group moderation for smaller (S) and larger (L) firm size groups[5]

	Firm Size (S)	**Firm Size (L)**	**z-score**
ABSCAP → INNO C EXPLOR	0,528 (***)	0,983 (***)	**
PROACT MKTOR → INNO C EXPLOR	0,327 (***)	NS	*

[5]Z-score significances: * p<0.05, ** p<0.01, *** p<0.001; NS=Not significant.

FIGURES

Figure 1. Main Theoretical Hypotheses of the Model.



APPENDIX

Appendix 1. Standard Loadings, Critical Ratios (C.R.).

Items	Std. Loadings	C.R.
Knowledge Acquisition		
We frequently acquire knowledge about technologies and market trends from external sources	0,856	1,00
We are able to identify and acquire external knowledge (e.g. market, technology) very quickly	0,839	19,95
Employees of our unit regularly visit other branches to learn about new technologies, trends, or business models	0,637	13,40
Knowledge Sharing		
Existing knowledge (e.g. market or technology) is readily available to each department	0,769	1,00
Our company periodically circulates codified knowledge in the form of documents to update its departments	0,645	11,42
When something important happens (market or technology development), the whole company knows about it in a short period	0,674	11,96
Knowledge Creation		
Our employees have the capabilities to produce many novel and useful ideas	0,785	1,00
Within this company, we have the capabilities to successfully learn new things	0,905	19,59
We have the capabilities to effectively develop new knowledge or insights that have the potential to influence product development	0,879	18,93
When solving problems, we can rely on good cross-departmental support	0,752	15,52
Labor Flexibility		
Employees are cross trained to perform a variety of activities	0,901	1,00
Workers operate various types of machines	0,746	17,63
Workers are cross trained in multiple cells/teams	0,880	23,09
Volume Flexibility		
We quickly change the quantities of our products produced	0,759	17,67
We vary the total output from one period to the next	0,813	19,57

We easily change the output volume of a manufacturing process	0,926	1,00
Routing Flexibility		
A typical part can be routed to alternate machines	0,804	14,27
A typical part can use many different routes	0,722	13,15
The system has alternative routes in case machines break down	0,787	1,00
Supply Chain Flexibility		
Suppliers adjust quantities without significantly increasing unit cost	0,801	1,00
Suppliers adjust quantities without significantly increasing lead time	0,746	18,10
Our suppliers adjust delivery times to changing requirements	0,880	16,54
Machine Flexibility		
Machines/tooling can be set up quickly	0,856	1,00
Machine set-ups are easy	0,749	12,31
Product Flexibility		
We produce different product types without major changeovers	0,740	15,54
We build different products in the same plant at the same time	0,743	15,63
We easily change from one product to another	0,889	1,00
Reactive Market Orientation		
We constantly monitor our level of commitment and orientation to serving customer needs	0,789	17,81
We measure customer satisfaction systematically and frequently	0,894	21,59
We have routine or regular measures of customer service	0,873	20,79
Proactive Market Orientation		
We help customers to anticipate developments in the markets	0,798	17,51
We incorporate solutions to unarticulated customer needs in our products and services	0,824	18,31
We search for opportunities in areas where customers have difficulty in expressing their needs	0,78	16,93
Innovation Competence Exploitation		
Over the last 5 years, my company...		
…upgraded current knowledge and skills for familiar products and technologies	0,851	20,71
…enhanced competences in searching for solutions to customer problems that are closed to established solutions rather than completely new solutions	0,837	20,17
…upgraded skills in product development processes in which the company already possessed significant experience	0,914	23,51
…strengthened our knowledge and skills for projects that improve efficiency of existing innovation activities	0,89	22,42
Innovation Competence Exploration		
Over the last 5 years, my company...		
…acquired entirely new technologies and skills	0,803	18,19
…learned product development skills and processes entirely new to the industry (e.g. product design, prototyping new products, timing new product introductions, customizing products for local markets, etc)	0,839	19,45
…acquired entirely new managerial and organizational skills that are important for innovation (e.g. forecasting technological and customer trends, identifying emerging markets and technologies, integrating R&D activities, marketing, manufacturing and other functions, managing the product development process)	0,82	18,76
…learned new skills for the first time (e.g. funding new technology, staffing R&D function, training and development of R&D and engineering personnel)	0,678	14,28