Agile Manufacturing

Moderator Effect between Workplace Flexibility, Innovation and Firm Performance

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Abstract

This paper develops a conceptual model to analyze the moderator effect that the evolution in the production system may have on the relationship between workplace flexibility and innovation performance at the firm level. We review the literature on workplace flexibility and agile manufacturing to propose several hypotheses that will be tested in a sample of manufacturing firms.

Introduction

Workplace flexibility includes human resource flexibility and outsourcing, and it is relevant to adopt innovative solutions in the firm because skill malleability or polyvalence implies that employees are able to respond in better ways to stimuli which have appeared previously, and that external sources of knowledge can be integrated from outsourcing. Workplace flexibility dimensions constitute a platform to build other levels of flexibility [1,2] that may also influence the innovation process in the firm.

However, prior research on workplace flexibility and innovation offers non-conclusive evidences of the flexibility-innovation relationship, mainly about the influence of external flexibility dimensions. Recent studies suggest the importance of moderator effects because the relationship between workplace flexibility and innovation may be greatly contingent. We extend this line of research by discussing the moderator effect of the typology of production systems on the workplace flexibility and innovation relationship.

The literature suggests that the ultimate requirement of world-class performance is the progression from traditional manufacturing to lean and then to agile manufacturing. Researchers, managers and consultants consider agile manufacturing the latest stage in the evolution of production models or systems. Agile manufacturing is a flexible production model that can adapt rapidly to changes in the business environment and can meet the needs of increasingly demanding and well-informed customers.

Some studies have already analyzed which production system influences more positively on firm performance. Nevertheless, despite the fact that agile manufacturing has frequently been promoted as a means of improving business competitiveness, prior research

has not analyzed yet the influence of agile manufacturing on innovation at the firm level. This paper contributes to the literature by developing a conceptual model that analyzes the moderator effect of the evolution in the production system on the relationship between workplace flexibility, innovation and firm performance.

Theoretical discussion – Workplace Flexibility and Innovation

Innovation is studied in many disciplines and has been defined from different perspectives. In a broad way, innovation is defined as the creation or adoption of new ideas, whereas at the organizational level, innovation is defined as the adoption of a new product, service, process, technology, policy, structure or administrative system [3]. Innovation can be the direct result of managerial choice or can be imposed by external conditions; but regardless of the internal or external origin of the impetus for change, innovation is intended to change the organization so that it maintains or improves its level of performance or effectiveness.

Wolfe [4] states that there can be no one theory of innovation and the researcher effort should be directed at determining the contingencies that govern when various innovation theories hold. Innovation cannot be understood without careful attention to the personal, organizational, technological, and environmental contexts within which it takes place.

The success of the innovation process depends not only on the firm's ability to exploit its resources but on exploring new not yet existing or at least fully realized dynamic capabilities [5]. A dynamic capability is the flexibility to manage changes and environmental fit [6]. Flexibility, a catchword in the discussions of the new organizations of the twenty-first century, is a complex, multidimensional, and difficult concept to define satisfactorily. The literature devotes much effort to defining and measuring various types of flexibility. Most definitions of flexibility refer to a firm's ability to meet a variety of needs in a dynamic environment. For instance, Wright and Snell [7] define flexibility as a firm's ability to quickly reconfigure resources and activities in response to environmental demands.

To attain the level of flexibility that customers value (i.e., quick delivery of a variety of innovative, high-quality, low-cost products), organizations must manage different types of flexibility that sometimes are interrelated and do not have the same importance in different competitive settings. An overview of the literature reveals that the taxonomy of flexibility is very extensive, due to the fact that this concept is widely applied to different areas of the organization. The type of flexibility that a firm should emphasize is related to its competitive environment and the firm resources. This article focuses on some flexibility dimensions that may influence the innovation performance of the firm.

In the context of operations, flexibility is most commonly associated with the literature about manufacturing flexibility which emerged in the 1980s and 1990s, and that focuses in particular on technological equipment and its potential for flexibility in terms of both breadth of input materials and output products, routing of throughput, and batch size. While valuable, this literature confines the study of flexibility to intra-organizational components (such as mix, product, volume and routing flexibility). Measures of product, process and new product flexibility may be used in the context of operations to analyze the innovation performance of the firm.

However, a growing body of the literature has begun to recognize that it is important to look beyond the flexible factory to the flexible supply chain [8]. With growth in outsourcing, companies are becoming increasingly reliant on service providers, blurring the traditional boundaries of the firm. In the context of the supply chain, the analysis of flexibility dimensions related to human resources and inter-firm relationships may offer a more direct explanation than technological factors of the variations in flexibility dimensions that can

impact innovation performance. For instance, Upton [2] found that employee's tenure in their position was related to product flexibility.

This article focuses on workplace flexibility dimensions because they constitute a platform to build other levels of flexibility [1,2] that may also influence the innovation process in the firm. Workplace flexibility includes human resource flexibility and outsourcing. These flexibility dimensions can support other flexibility dimensions at operational and organizational level. For instance, employees with multiple skills (*functional flexibility*) may contribute through multifunctional teams to accelerate the process of new product development (*new product flexibility*). Some authors even claim that labor flexibility is the most important form of flexibility [2].

The dimensions included in workplace flexibility can be classified in internal and external (table 1). Internal workplace flexibility involves efforts to increase the firm's ability to adjust to changing circumstances through modifications of the internal labor market or work organization (functional flexibility and internal numerical flexibility), whereas external workplace flexibility uses changes in the external labor market (external numerical flexibility) and outsourcing. This classification is useful to understand the implications of workplace flexibility for innovation performance, and constitutes a base for the development of our research model.

Table 1. Types of workplace flexibility

Type of flexibility	Strategic focus	
	External	Internal
Volume of labor	"Numerical flexibility" E.g. frequent layoffs and recalls	"Working time flexibility" E.g. flexitime, planned overtime or short time
Organization of work	"Externalization" E.g. outsourcing	"Functional flexibility" E.g. multiskilling

We can relate the importance of internal and external workplace flexibility to the relative importance of innovation activities in the firm, but the literature offers non-conclusive results about the association between workplace flexibility dimensions and innovation. Whereas some theoretical perspectives and empirical results suggest the need to build and sustain committed human resources with full-time and permanent contracts, others argue that looser employment relationships and outsourcing could be beneficial for innovation because they would exert a discipline upon labor which counteracts complacency and rigidity; these looser employment relationships enable firms to gain access to an array of diverse specialists, filling identified knowledge gaps which it could not afford to engage on a full-time, permanent basis.

Thus, Atkinson's [9] model of the flexible firm differentiates between the core employees who are most vital to the firm because they are involved in activities that generate core competences, and the periphery employees who are less important because they perform activities that generate non-core competences. Employees in core value-creation areas are responsible for innovation activities, and Atkinson [9] suggests that firms will seek to secure and promote these employees and protect them from adjustments to environmental uncertainties. In the core, internal flexibility may foster employees´ innovation behavior and organizational commitment. On the contrary, peripheral activities that do not contribute to innovation and are not in need of long-term relationships can be outsourced or managed by external work arrangements. In the periphery, external flexibility is useful to accommodate changes in the firm environment throughout temporary employment or outsourcing of activities. Emphasizing secure, long-term and high-commitment-based employment policies would be more conducive to innovation, whereas flexible work practices, such as external work arrangements or outsourcing, could damage innovation performance.

The core competences approach suggests that firms should invest in those activities constituting core competences and outsource the rest. Some major new product and process developments (e.g., radical innovations and complex technological products) are core-related activities that may have high transaction costs which means that in-house R&D and proprietary innovations should not be carried out through outsourcing and/or external work arrangements but by employees in core value-creation areas with secure employment and functional flexibility. The in-house development of activities may be an efficient mechanism for the creation of new core skills and capabilities that may be lost if their development is entrusted to external agents [10].

However, the increasing complexity of markets makes difficult for firms to have all of the resources necessary to innovate. Outside knowledge sources are sometimes the only option for firms that wish to keep up-to-date. This line of argument begins to suggest that even quite extensive use of flexible employment contracts or outsourcing may be perfectly compatible with the achievement of innovation in dynamic and high-technology environments to ensure the presence of knowledge resources that may be beyond existing internal capabilities.

Outsourcing and contingent employees may bring new knowledge to the organization, and complement innovation capabilities of core employees with internal flexibility. Thus, Nesheim [11] and Nesheim et al. [12] found that firms in dynamic environments use external personnel and consulting firms in core value-creation areas to bring knowledge and industry 'best-practices' into the firm. Mol [13] also found that high R&D-intensive industries increased more their level of outsourcing than low R&D-intensive industries in the 1990s.

Therefore, there is an opportunity here to research the impact of workplace flexibility on innovation performance, and the moderator role of some variables on this relationship. We want to contribute to the literature and reconcile theoretical perspectives by analyzing the moderator effect of the evolution in the production system on the relationship between workplace flexibility and innovation performance at the firm level. Previously we review the concept of agile manufacturing as an evolutionary paradigm of production organization in the firm.

Theoretical discussion – Agile Manufacturing

The literature suggests that agility is a concept coined to address competitiveness in the current fast-paced and unpredictable industrial environment. Although agility shares a common component of meaning with flexibility, the literature (see [14] for a recent review) indicates that the latter has been used to indicate the ability to manage uncertainty by having available options within an existing configuration and predetermined constraints. Agility seems to be a philosophical approach to organizing and managing manufacturing, whose identifiable characteristics have only recently started to be addressed empirically [15-17]. At the organizational level, whereas flexibility is the ability of a manufacturing system to accommodate change by modifying status within those pre-specified parameters, agility can be characterized by the attribute of reconfigurability of the system itself to deal with unpredictable change. As a concept, agility in manufacturing identifies a production model that is conditioned by changes in the environment and links innovation in manufacturing, information and communication technologies with a radical organizational redesign, new human resources practices and the application of new marketing strategies.

Agility focuses more on innovative response, as it addresses unpredictable changes. Some firms are responding more quickly than ever before to changing technological and market opportunities by introducing a greater number of new products, offering broader product lines, and upgrading products more rapidly. Narasimhan et al. [15] conceptually

differentiate agility from agile manufacturing systems, where agility is proposed as a performance capability, while agile manufacturing systems refers to a cluster of related practices. Furthermore, agility has been differentiated from other manufacturing paradigms like lean manufacturing in that the latter is a response to competitive pressures with limited resources, while the former is a response to complexity brought about by constant and typically unforeseen changes. Agile manufacturing can be considered a production model that integrates technology, human resources and the organization through information and communication infrastructures that provide flexibility, speed, quality, service and efficiency and enables firms to react deliberately, effectively and in a coordinated manner to changes in the environment [16].

Then, the evolution and dynamic change of operations from a traditional manufacturing system, towards a lean manufacturing system, and eventually to an agile manufacturing system, could influence the impact of workplace flexibility on innovation. The literature consistently suggests that traditional, leanness and agility manufacturing are identifiable, distinct, operational performance capabilities that explain fundamental differences in plant operational performance. However, the literature also suggests that lean and agile manufacturing paradigms involve the deployment of a common subset of manufacturing practices, and that there may be temporal relationships between lean manufacturing and agile manufacturing in a performance/practice state that is antecedent to agile manufacturing. Both the economies of knowledge perspective and the evolutionary perspective of production systems suggest that leanness might be a precursor to agility [15]. In terms of practices, lean manufacturing does not imply agile manufacturing, yet agile does imply that many of the principles and techniques of lean manufacturing are in place.

Brown and Bessant [18] argue that TQM and JIT, practices normally associated with lean manufacturing, provide vital foundational capabilities for agile manufacturing. Both lean manufacturing and agile manufacturing are associated with worker cross-training and empowerment, use of teams and cells, development of special supplier relationships, and a strong manufacturing strategy. Agile manufacturing is presented as placing increased emphasis on supplier cooperation, information technology, and employee flexibility. Similarly, other scholars indicate that while lean manufacturing and agile manufacturing address the same set of manufacturing competitive priorities (cost, quality, lead time, service level), they emphasize different elements.

The above discussion suggests that lean manufacturing and agile manufacturing are distinct, yet overlapping paradigms. Through a case study analysis, McCullen and Towill [19] imply that agile manufacturing can be a precursor to lean manufacturing. On the other hand, other writers suggest an opposite hierarchical or temporal relationship. Similarly, in tracing the evolution and ‘‘chronology’’ of manufacturing paradigms (craft production mass production lean/JIT production agile production), Harmozi [20] suggests that the ultimate requirement of world-class performance is the progression from lean manufacturing to agile manufacturing.

Therefore, the evolution of the firm towards the agile manufacturing paradigm may have positive effects on business performance and specifically on innovation performance, and at the same time it may reinforce the positive contributions of workplace flexibility to innovation. The next section develops research hypotheses based on a model that links workplace flexibility, agile manufacturing, and innovation performance.

Hypotheses

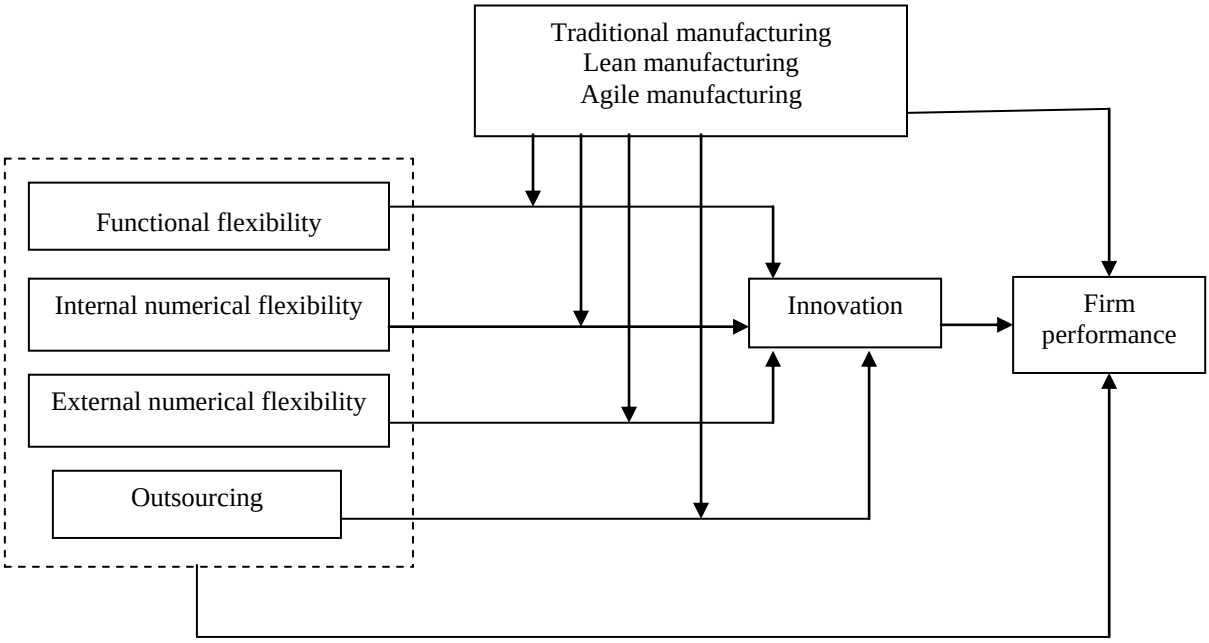
We develop a comprehensive set of hypotheses that relate each dimension of workplace flexibility to innovation performance. Then we discuss how the level of traditional,

leanness or agility in the firm's manufacturing system may influence these relationships. Agile manufacturing is a more flexible approach towards inter-firm cooperation and the development of creative skills by the management and the workforce, generating an adaptable, competitive and innovative organization. We will empirically assess the level of agility, leanness or traditional in the firm's manufacturing system by the average use of a comprehensive set of manufacturing practices.

Our conceptual model (Figure 1) proposes that functional and internal numerical flexibility are positively related to innovation performance, whereas the influence of external numerical flexibility and outsourcing depends on the type of contingent employee and the strategic level of outsourcing. Regarding the moderator effect of agile manufacturing, we propose that the greater the level of agility in the firm's manufacturing system, the more positive the relationship between internal (functional and internal numerical) flexibility and innovation. The moderator effect on external flexibility and outsourcing depends on the level of knowledge required or developed by each dimension. High-strategic outsourcing and knowledge-intensive external flexibility may influence innovation more positively in agile environments than in traditional manufacturing environments. Agile environments need more deployment and access to knowledge than traditional manufacturing environments in order to accommodate changes in the business environment and the increasingly demanding needs of well-informed customers. On the contrary, other dimensions of external flexibility and outsourcing less intensive in knowledge-content may be less influenced by the level of traditional, leanness and agility in the firm's manufacturing system because they can not benefit from the set of manufacturing practices included in the production system. The next paragraphs develop these research hypotheses.

The first flexibility dimension included in the model is functional flexibility. Functional flexibility means a process through which firms adjust to changes in the demand for their output by an internal reorganization of workplaces based on multiskilling, multitasking, teamwork and the involvement of employees in job design and the organization of work. There are at least two causal mechanisms that can explain how functional flexibility may contribute to innovation performance. First, functional flexibility may enhance the employee's innovation behavior through increased organizational commitment. Functional flexibility can improve the quality of working life by reducing monotonous, repetitive work. Besides, the practices that promote functional flexibility are supported by some human resource policies such as lifetime employment and on-the-job training that contribute to develop the employees in the core workforce. Secondly, the use of some functional flexibility practices may contribute to a wider dispersion of knowledge and hence to improve innovation performance [21]. For instance, multiskilled teams make the deployment of individual workers to particular tasks more adaptable but, at the same time, can improve the firm's innovation performance by leveraging the innovative behavior of individual employees, and by developing new products in cooperation between different departments and firms. Both causal mechanisms –increased organizational commitment and increased dispersion of knowledge- may be direct outputs from functional flexibility practices that lead to increased innovation.

Figure 1. Research model



Hypothesis H1a. The greater the firm´s functional flexibility, the greater the firm´s innovation performance.

The proposed positive relationship between functional flexibility and innovation performance may be moderated by the level of agility in the firm's manufacturing system. Given that functional flexibility involves the deployment of employees´ skills and abilities, firms in more agile manufacturing environments should need a wider dispersion of knowledge. Agile manufacturing needs multi-function teamwork to be an integral part of the firm's culture, allowing highly trained and qualified workers to take decisions on their tasks, using advanced technological tools and having access to extensive information regarding the firm's objectives and strategies. Teamwork is a necessary element for improving the firm's responsiveness to variations in medium and long-term market conditions. For correct implementation, agile manufacturing needs: (a) broaden job responsibilities, (b) increase the versatility, responsibility and decision-making capability of workers, and (c) encourage self-management processes amongst the teams and workers. Then, agile manufacturing may positively moderate the relationship between functional flexibility and innovation.

Hypothesis H1b. The greater the level of agility in the firm's manufacturing system, the more positive the relationship between functional flexibility and innovation performance.

The second workplace flexibility dimension in Figure 1 is internal numerical flexibility. This flexibility is related to adjusting work volume to changes in demand through part-time contracts or flexible working hours. This flexibility may also contribute positively to innovation performance because innovation behavior can be facilitated if employees are more committed to their organization. Employees require flexitime (working-hour flexibility) to visit children' schools or work part time temporarily at certain points in life. Workplace practices like flexitime may increase job satisfaction and organizational commitment of core employees, which in turn will derive in enhanced innovation behavior. Even part-time

employees, especially if they have chosen this form of employment, report a more positive 'psychological contract' and a potential higher propensity for innovation. Thus, the availability of these workplace flexible practices (flexitime, etc.) and the organizational support to use them may enhance innovation behavior of core employees involved in innovation activities.

Hypothesis H2. The greater the firm´s internal numerical flexibility, the greater the firm´s innovation performance.

Regarding the moderator effect of agility, although there is less knowledge deployed than in functional flexible practices, the level of agility may still moderate the relationship between internal numerical flexibility and innovation. Flexible practices like flexitime are mostly used by core employees who are the most closely associated to innovation activities. Agile manufacturing environments need to accommodate more changes in the organization of work, and to mitigate the work-family conflict of core employees in such environment. Human resources are considered a key element of the factory's agility and, in order to strengthen their results, emphasis is placed on training, empowerment and flexitime [22]. Then, the proposed positive link between internal numerical flexibility and innovation, may be further enhanced under agile than under traditional manufacturing environments.

Hypothesis H2b. The greater the level of agility in the firm's manufacturing system, the more positive the relationship between internal numerical flexibility and innovation performance.

The third dimension of workplace flexibility in Figure 1 is external numerical flexibility. This flexibility adjusts the firm's output by contracting and firing temporary employees: short-term hires, temporary help agencies and consulting/contracting firms. Each type of external work arrangement may have different implications for innovation performance. First, short-term hires may contribute to reduce labor costs but they may also have negative outcomes. Innovation requires organizational commitment that it is less frequently found among short-term hires [23]. For instance, Broschak and Davis-Blake [24] find that the percentage of short-term hires is negatively related to employee trust, internal workers´ attitudes and the quality of employee-supervisor relationship which may negatively influence innovation at the firm level.

Hypothesis H3a. The greater the firm's level of short-term hires, the lower the firm's innovation performance.

Second, firms can lease employees from temporary help agencies for the same reasons than short-term hires. These employees may also represent a threat to job security, indicating firm cans easily get someone else to do the same job which can affect the stigmatization of temporary employees. External workers are more difficult to organize and often have different objectives from those of the permanent workers, making collective bargaining difficult which may negatively influence labor relations and discretionary efforts. These employees are also normally excluded from in-house training programs which make them less productive for new product development teams which negatively influence innovation at the firm level.

Hypothesis H3b. The greater the firm's level of employees from temporary help agencies, the lower the firm's innovation performance.

Third, firms may use consulting/contracting firms or universities/R&D centers to provide numerical flexibility and obtain knowledge. These external employees bring knowledge of occupational and industry best practices into the firm, and may stimulate exploration of ideas outside the firm's knowledge stock [11]. This flexibility increase opportunities for much faster and lower-cost innovation to firms that develop their core competences and integrate outside knowledge properly. Hoecht and Trott [25] indicate that hiring specific individuals with tightened legal contracts is a better option to benefit from external knowledge than networking. Then, we propose the following hypothesis:

Hypothesis H3c. The greater the firm's use of consulting/contracting firms, the greater the firm's innovation performance.

Regarding the moderator effect of agility on external numerical flexibility, the first two dimensions -short-term hires and temporary help agencies- are primarily related to the adjustment of employment volume to accommodate output changes. Firms in agile manufacturing environments may need more adjustments than firms in traditional manufacturing environments. If agile manufacturing raises the rotation of temporary employees, then the negative influence of short-term hires and temporary help agencies would be enhanced in terms of lower organizational commitment which in turn would negatively affect innovation performance. Then, we propose:

Hypothesis H3d. The greater the level of agility in the firm's manufacturing system, the more negative the relationship between the use of short-term hires and innovation performance.
Hypothesis H3e. The greater the level of agility in the firm's manufacturing system, the more negative the relationship between the use of temporary help agencies and innovation performance.

The third dimension of external numerical flexibility –consulting/contracting firms and R&D centers- involves the access to relevant knowledge. The misfit between a firm's existing capabilities and the firm's operational environment may be mitigated if the firm can explore new areas and build new capabilities. Firms engaging in continuous exploration of knowledge are likely to have technical groups with varied perspectives and are then better able to reframe problems and overcome competitive traps when the environment demands organizational change. Agile manufacturing implements strategic outsourcing to focus factories on their core competences which implies the incorporation of research centers and suppliers in the early stages of new product development processes. The most important results of this initiative can be seen in the reduction of development times, better adaptation of the product to specific customer needs and improvement of product manufacturability [22]. Thus, we propose a positive moderator effect of agility:

Hypothesis H3f. The greater the level of agility in the firm's manufacturing system, the more positive the relationship between the use of consulting/contracting firms and innovation performance.

Finally, the last workplace flexibility dimension depicted in Figure 1 is outsourcing. According to transaction cost theory, a high R&D intensity should lead to lower levels of outsourcing because there can be an increased risk of opportunism if innovation activities are not performed inside the firm, especially when the R&D concerned is of a proprietary rather than a generic nature. As a result, firms that outsource are likely to lose gradually touch with

new technological breakthroughs that offer opportunities for product and process innovations. In addition, as suppliers gain knowledge of the product being manufactured, they may use that knowledge to begin marketing the product on their own.

Firms in agile environments increasingly use cooperative relations with outside suppliers to obtain technology in areas that they know of, but are not themselves specialized in. The use of outside suppliers and technology partners creates the option to access a much larger productive knowledge pool. However, outsourcing work is not automatically linked to cooperation because, for example, arm-length buyer-supplier relationships are not characterized by supplier involvement in design, R&D or innovation at all. Only some partnership buyer-supplier relationships are simultaneously characterized by outsourcing and technological or R&D cooperation. What we want to propose here is that the level of agility in the firm's manufacturing system can moderate the negative impact of outsourcing on innovation performance. Therefore we hypothesize that outsourcing is negatively correlated to innovation performance but that the level of agility moderates this relationship and decreases the negative impact of outsourcing on innovation performance.

Hypothesis H4a. The greater the firm's intensity of high-strategic outsourcing, the lower the firm's innovation performance.
Hypothesis H4b. The greater the level of agility in the firm's manufacturing system, the less negative the relationship between high-strategic outsourcing and innovation performance.

Conclusion

The paper deals with important issues and questions that need to be addressed to understand how agile manufacturing could contribute to innovation performance at the firm level. Firms are starting to become aware of the importance of agile manufacturing, but have not extensively linked the concept to concrete actions yet. Our paper will contribute to support theoretically the positive influence of agile manufacturing to the variables depicted in the research model. The empirical study based on this paper will contribute to the line of research that tests the influence of agile manufacturing on firm performance but it also extends this contribution by focusing the impact of agile manufacturing on innovation.

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