Int. J. Production Economics 143 (2013) 242–247

Contents lists available at SciVerse ScienceDirect

Int. J. Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Linking manufacturing flexibility to innovation performance in manufacturing plants

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ARTICLE INFO

Available online 14 September 2011

Keywords:
Mix flexibility
Labor flexibility
Innovation
Manufacturing

ABSTRACT

In the past few decades, the concept of manufacturing flexibility has become a key competitive criterion for many manufacturing organizations. The importance of flexibility in supporting other competitive criteria such as cost, quality and delivery speed has also been recognized (Bolwijn and Kumpe, 1990). However, there is a dearth of studies linking flexibility with another competitive criterion—innovation. In this study, we investigate the influence of the interaction of mix flexibility and labor flexibility on product innovation based on a survey of UK manufacturing plants. Further, we investigate the role of climate for innovation both as an antecedent of product innovation and a moderator that moderates the influence of the interaction of mix flexibility and labor flexibility on product innovation. The analyses reveal that the interaction of mix flexibility and labor flexibility positively predicts product innovation in manufacturing plants. Climate for innovation positively predicts product innovation and also positively moderates the interaction of mix and labor flexibility on product innovation. The implications for theory and practice are discussed.

1. Introduction

In the past few decades, the concept of manufacturing flexibility has become a key competitive criterion for many manufacturing organizations. As such, there has been a plethora of studies on various aspects of flexibility including studies on flexibility taxonomies (Slack, 1987; 1991; Koste and Malhotra, 1999; D'Souza and Williams, 2000), flexibility drivers, enablers and implementation (e.g. Suarez et al. 1996; Jack and Raturi, 2002; Oke, 2003, 2005) and measures of flexibility (e.g. Cox, 1989; Koste et al., 2004). The importance of flexibility in supporting other competitive criteria such as cost, quality, delivery speed and innovation has also been recognized (Bolwijn and Kumpe, 1990). Likewise, there have been many studies on different types of innovation in the extant literature (e.g. Oke, 2007). Indeed the operations management literature has often treated both innovation and flexibility as competitive criteria. In other words, they are seen as the outcome variables or as operations performance objectives of firms. However, we are not aware of any empirical study that has attempted to link the two. Yet, it has been argued that while a manufacturing plant can attain flexibility state without having to be innovative, the reverse is not true. In other words, flexibility is a necessary ingredient for innovation (Bolwijn and Kumpe, 1990).

As such, our objective in this study was two-fold. First, we investigated the relationship between flexibility and product innovation performance. In this proposed relationship our focus is on two aspects of flexibility (1) mix flexibility, which we define as "the ability of the organization to produce different combinations of products economically and effectively given certain capacity"(Zhang et al., 2003, p. 177) and (2) labor flexibility, which we define as "the ability of the workforce to perform a broad range of manufacturing tasks economically and effectively" (Zhang et al., 2003, p. 177). We investigated the effect of the interaction term of mix flexibility and labor flexibility on product innovation. Our second objective was to investigate the conditions under which the interactive term of mix flexibility and labor flexibility will more or less predict product innovation performance. We identify climate for innovation not only as an antecedent of product innovation performance but also as a potent moderator in the relationship. We define climate for innovation as an environment or a culture that encourages creativity and innovation through positive recognition, support and rewards systems. Our study partly fills the theoretical gap between flexibility and innovation. The rest of the paper is structured as follows. First, we review the literature on flexibility and innovation from which we formulated the first hypothesis. Next, we review the literature on climate for innovation and formulated the second and third hypotheses. We then present the methodology, the analysis and results. We conclude the study

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0925-5273/$ - see front matter Published by Elsevier B.V.
doi:10.1016/j.ijpe.2011.09.014

by discussing the study contributions, implications, limitations and future research areas.

2. Mix flexibility, labor flexibility and product innovation

In this study, we attempt to establish the link between the interactive term of mix flexibility and labor flexibility and product innovation. Mix flexibility has been identified as one of the important dimensions of manufacturing flexibility (Malhotra and Ritzman, 1990; Suarez et al., 1996; Koste et al., 2004; Oke, 2005). Suarez et al. (1996) identified mix flexibility as a first-order flexibility type that has the capability of directly impacting a firm's competitive position. This is consistent with an earlier work by Slack (1991) who identified mix flexibility as a manufacturing system flexibility type that has the capability of directly affecting competitiveness. Oke's (2005) framework provides further support to Slack's taxonomy. He identified mix flexibility as a system flexibility type that depends on other factors including changeover times, product modularity, labor skills, process technology, supply chains and information technology. Oke (2005) noted in particular that mix flexibility has a direct effect on the competitive performance objectives of manufacturing firms. Similarly, Zhang et al. (2003) identified mix flexibility as an external element of competition that directly affects customer satisfaction. According to Zhang et al. (2003, p. 179), customer satisfaction can be defined as "the degree to which customers perceive that they received products and services that are worth more than the price they paid". They noted that customer satisfaction can be influenced by manufacturing performance objectives including quality, delivery speed, delivery dependability, cost, flexibility and innovation. In sum, the link between mix flexibility and performance has, in general, been discussed but its link with product innovation has not been empirically investigated. Compared to mix flexibility, labor flexibility has received less attention in the operations management literature. The primary source of labor flexibility is cross-training or multi-skilling (Oke, 2005). As Zhang et al. (2003) noted, the workforce actually plays an important role in the production process and its consequences on system flexibility and performance has been the subject of a few empirical studies (Hyun and Ahn, 1992; Ramasesh and Jayakumar, 1991; Upton, 1995; Jack and Raturi, 2002).

In the operations management literature the performance of manufacturing firms has been typically measured based on the performance objectives identified by Zhang et al. (2003) above (e.g. Schroeder, et al., 1986; Miller and Roth, 1994; Koufteros, 1995; Tracey et al., 1999; Ahmad and Schroeder, 2003 to name a few). Similarly, a few studies have examined the performance implications of flexibility (Swamidass and Newell, 1987; De Meyer et al., 1989; Pagell and Krause, 2004). While these studies have been beneficial to our understanding of flexibility as a strategic competitive weapon, they tended to treat flexibility and performance as uni-dimensional constructs. Yet, several studies have highlighted the multi-dimensional nature of manufacturing flexibility (e.g. Brown et al., 1984; Slack, 1987; Hyun and Ahn, 1992; Suarez et al., 1996; Koste et al., 2004; Oke, 2005). Further, proponents of the manufacturing objectives trade-off argument have argued that priorities often exist among the competitive objectives depending on what is most valued by the customer (Lee, 1992; Vokurka and Davis, 2000). Firms, they argue can ensure superior performance by focusing on specific competitive priorities (Skinner, 1974). As such, there is a need to investigate the impact of flexibility on product innovation—a key strategic competitive objective of manufacturing firms.

We focus on product innovation as the outcome variable in this study because, of all the competitive objectives, product innovation has received the least attention as a competitive objective of manufacturing firms in the operations management literature. Yet the importance of innovation as a competitive criterion of manufacturing firms cannot be overemphasized. We have argued that having mix flexibility means that a firm is able to produce a wide variety of different types of products (Pagell and Krause, 2004) because components of mix flexibility include material handling flexibility and machine flexibility (Oke, 2005; Zhang et al., 2003). Similarly, we have argued that having labor flexibility means that the workforce is able to perform a variety of task because the employees are cross-trained. We posit that such cross-trained employees may be able to utilize and tap from the varieties of skills that they possess to tackle problems and generate new product ideas. Further, achieving both mix flexibility and labor flexibility requires cross-functional integration since different products may require inputs from different functions. Such cross-functional integration involves the sharing and integration of diverse pool of information and knowledge that could lead to new ideas for creating new products. The flexibility of the machinery required to deliver mix flexibility enables new product ideas to be quickly developed to achieve product innovations.

In sum, our general thesis is based on the fact that labor flexibility exposes the workforce to a broad range of manufacturing tasks, which can expand the workforce repository of skills and knowledge. The rich repository of skills and knowledge increases the chances of creating new product ideas. However, because product innovation involves both the creation and development of product ideas, we posit that the capability to generate new product ideas through the required labor skills must be combined with the ability of the firm to quickly produce or develop different new product ideas (mix flexibility) in order to influence product innovation performance. In support of this thesis, Slack et al. (2001) argue that in order to satisfy customers' needs for new products, an operation must have a high degree of flexibility. As such, we posit that the degree of mix flexibility of an operation combined with the degree of labor flexibility will positively influence product innovation performance leading to the first hypothesis of the study.

H1:. *Mix flexibility will interact with labor flexibility to positively predict product innovation performance in manufacturing plants.*

3. Climate for innovation and product innovation

The climate of an organization can be said to be indicative of the way the organization runs itself. This may be reflected through the organization's practices, procedures and rewards systems (Ahmed, 1998). In this study, we define climate for innovation as an environment that is the outcome of the practices and reward systems that are put in place to recognize and encourage creativity and innovation. Amabile (1998) argues that motivation (in particular intrinsic motivation—"a person's internal desire to do something") is a fundamental enabler of creativity and innovation. Such intrinsic motivation can be influenced by practices that build the climate for innovation including challenge, freedom, encouragement, recognition and organizational support (Amabile, 1998). For example, recognizing the achievements of individuals or teams builds the confidence of the individuals or teams to try out new things, conduct deep searches that may lead to new product ideas. By allowing the freedom to take risks and experiment (O'Reilly and Tushman, 1997), individuals are able to carry out deep explorations and "outside of the box" thinking that may help to generate new product ideas. In support, Bharadwaj and Menon (2000) argue that organizational creativity mechanisms including formal approaches to encourage