



# The labor–machine dyad and its influence on mix flexibility

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## Abstract

The joint, mediating, and interactive effects of three elements of labor and machine flexibility on mix flexibility were tested empirically in a PCB assembly plant. Both subjective and objective data were collected. Some elements of labor and machine flexibility mediated the relationship between an emphasis on competitive priorities and mix flexibility. The interactive effects of machine and labor flexibility on mix flexibility confirmed prior findings that the pursuit of total flexibility is not desirable. For low levels of labor flexibility, increasing machine flexibility yields at the most a very moderate improvement in mix flexibility. When labor flexibility is high, increasing machine flexibility proves to be counter-productive. These results may suggest that the traditional forms of labor flexibility need to evolve when technological capabilities are more fully exploited.

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## 1. Introduction

Manufacturing flexibility is often construed as the ability to respond quickly to change with minimum penalty (Gerwin, 1993; Koste and Malhotra, 1999). Despite being touted as an important strategic weapon, flexibility is not formally managed like quality and cost (Cox, 1989; Zammuto and O'Connor, 1992). Two problems engender this phenomenon: measurement

deficiencies and the ensuing lack of empirical research. Flexibility remains an abstract concept to most manufacturers, and its measures tend to be industry or even sample-specific (Dixon, 1992). Nevertheless, the past years have witnessed constructive measurement efforts with the development of taxonomies identifying the facets of this multi-dimensional construct (Buzacott, 1982; Slack, 1983, 1988; Gerwin, 1987; Sethi and Sethi, 1990; Gupta and Somers, 1992; D'Souza and Williams, 2000). A dominant perspective in analyzing the relationships among these facets has been the hierarchical view (Browne et al., 1984; Slack, 1987; Sethi and Sethi, 1990; Hyun and Ahn, 1992; Suarez et al., 1996; Koste

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and Malhotra, 1999). According to this view, resource flexibilities (labor and machine) are the lowest level dimensions and serve as the building blocks of the hierarchy. Although this hierarchical model is conceptually sound, there is only sparse evidence to support it. Moreover, the hierarchical model does not capture the antecedents of resource flexibility. There is a general consensus that resources are aligned to enable the achievement of excellence in the competitive priorities, i.e., cost, quality, time, and flexibility (Miles and Snow, 1984; Jackson et al., 1989; Cappelli and Singh, 1992; Hayes et al., 2005). Unfortunately, scarce empirical evidence also afflicts this line of research. The purpose of this study is to fill these gaps by: (1) focusing on the sound operationalization of labor, machine, and mix flexibility; (2) examining the influence of competitive priorities on resource alignment; and (3) testing the premise of the hierarchical model that labor and machine flexibility contribute to a higher-level capability, i.e., mix flexibility. Further justification for this endeavor is provided below.

The recent focus on flexibility does not seem to have eclipsed the importance of other competitive priorities, as the trade-off approach might suggest (Skinner, 1966; Hayes and Wheelwright, 1984; Hill, 1994; Porter, 1996). Rather, some argue that the maturation of the quality movement and its impact on overcoming conformance deficiencies have enabled progressive manufacturers to devote more efforts to the active pursuit of flexible operations (e.g., Gerwin, 1993). This view is consistent with the cumulative model which states that organizations can excel on multiple competitive priorities simultaneously, with quality paving the ground for the development of the other capabilities (Nakane, 1986; Ferdows and De Meyer, 1990; Noble, 1995). Interestingly enough, this perspective shares a resemblance with the hierarchical model of flexibility. In a nutshell, this model purports that resource (machine and labor) flexibility supports flexibility at the shop floor level which, in turn, supports flexibility at the plant level in order to promote the overall flexibility of the manufacturing function (e.g., Koste and Malhotra, 1999). Both the cumulative model and the hierarchical model are based on the sequential development of capabilities. Additionally, the competitive priorities articulated in the cumulative model are precursors to the hierarchical model since they shape the resource capabilities or

foundations of the flexibility pyramid. Notwithstanding these conceptual relationships, no empirical research has linked the competitive priorities to labor and/or machine flexibility.

Fertile grounds for dual-resource constrained (DRC) system research, machine and labor flexibility have simply not sparked comparable levels of interest in the field-based empirical research. The situation is especially acute for labor flexibility despite academics' repeated pleas to put it on the empirical research agenda (Treleven, 1989; Chen et al., 1992; Vokurka and O'Leary-Kelly, 2000). Even the claim that labor and machine flexibility support mix flexibility (i.e., the ability to respond to product mix changes in the market) is barely substantiated. In an extensive review of the literature on manufacturing flexibility, Koste and Malhotra (1999) identified 11 papers that discussed the relationship between machine and/or labor and mix flexibility. Of those papers, only four were empirical. One was qualitative in nature (Slack, 1987), another one was a simulated experiment that addressed only machine flexibility (Boyer and Leong, 1996), and the other two were based on the same sample (Suarez et al., 1995, 1996) and used surrogate measures of machine flexibility. A possible reason for this void is that the operationalizations of both labor and machine flexibility are still tentative at best.

In this empirical study, we integrate two general operations strategy theories to provide a more comprehensive view of the mechanisms driving mix flexibility. Consistent with the cumulative model, we posit that all competitive priorities are compatible with the production of a varied mix. However, we speculate that this relationship is not a direct one. Emphases on competitive priorities may filter through the lens of the resource capabilities to influence mix flexibility. One objective of this paper is to examine the nature of this influence. The second and main objective focuses on the specific contributions of the resource flexibilities to mix flexibility. Accordingly, we distinguish among the main, mediating, and interactive effects of machine and labor flexibility on mix flexibility. Special attention is devoted to their measurement by using objective measures to validate, refine, or even question current operationalizations of flexibility. A brief description of the organization of the paper is presented below.

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