

Interplay between uncertainty and flexibility across the value-chain: Towards a transformation model of manufacturing flexibility

Rajeev Sawhney*

Department of Management, College of Business and Technology, Western Illinois University, Macomb, IL 61455-1390, USA

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Abstract

Traditionally, flexibility, in its reactive application, has been viewed as a coping mechanism against uncertainty in an organization's internal or external environment. It has also been shown that flexibility can be utilized proactively to create a competitive advantage for a company. Despite the recognition that it serves a dual purpose, little work has been done to synthesize these competing uses of flexibility. This study proposes a model that not only articulates an effective use of flexibility concurrently for both proactive and reactive purposes, it also allows a simultaneous view of the opportunities and uncertainties along the value-chain. By embracing the entire value-chain, this model considers the implications of the inter-relating feedback loops within the supply-chain, which to-date has been overlooked in the flexibility literature. Such an approach provides managers with a tool that allows them to consider more options in configuring flexibility between its two competing uses. Within the model, eleven dimensions of flexibility are identified and then classified into three levels comprising a transformation process. This model is grounded in observations from a field study of 10 printed circuit board (PCB) fabrication companies.

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1. Introduction

Flexibility is defined as the ability to react or transform with minimum penalties in time, cost, and performance (Upton, 1997). Traditionally, flexibility, in its reactive use,¹ has been viewed as a coping mechanism against uncertainty in an organization's internal or external environment (Beach et al., 2000; Collins et al., 1998; Gerwin, 1983; Gupta and Somers, 1996; Mackenzie,

1998; Milliken, 1987; Swamidass and Newell, 1987). Such uncertainties manifest themselves in the form of equipment breakdowns, variable task times, queuing delays, rejects and reworks, labor absenteeism and turnover, material mishandling, fluctuations in demand, product mix, actions of competitors, etc.

More recently, researchers (Chang et al., 2003; Ettl and Penner-Hahn, 1994; Sanchez, 1995; Upton, 1997) have argued that flexibility can also be utilized proactively to create a competitive advantage for a company. There are numerous examples of this profitable implementation of flexibility — Ford's experiment in Europe (Shirouzu, 2002), General Motors' Lordstown plant (Kasarda and Rondinelli, 1998), and the National Bicycle Industrial Company (Moffat, 1990).

Despite the recognition that flexibility can be employed both reactively and proactively in meeting

* Tel.: +1 309 298 1625; fax: +1 309 298 1019.

E-mail address: rsawhney@wiu.edu.

¹ This manuscript uses the words 'reactive' and 'proactive' to describe the negative and positive aspects of uncertainty and opportunity, respectively, when allocating flexibility. An alternative interpretation, not utilized in this manuscript, refers to the sequence of flexibility allocation, either ex-post or ex-ante.

the needs of an organization, little work has been done to synthesize these two competing uses. However, understanding this concurrent application is important, because flexibility does not come free; and any strategic investments in flexibility based on poorly considered ‘competencies’ could be detrimental (Gerwin, 1993; Narasimhan et al., 2004; Slack, 1988).

This paper contributes to the flexibility literature by proposing a transformation framework that articulates how managers can configure flexibility simultaneously between the proactive and the reactive uses that coexist in a firm’s day-to-day operations. It also considers the implications of the inter-relating feedback loops within the supply-chain, which to-date have not been addressed in the flexibility literature (Handfield and Nichols, 2002; Oke, 2003; Vickery et al., 1999; Zhang et al., 2003). This value-chain approach is more applicable for managers as it provides additional options in configuring flexibility, and allows decisions made in one segment to complement those made in other segments of the value-chain (Mabert and Venkataraman, 1998). Within the proposed model, eleven flexibility dimensions are identified from the actual functioning of the printed circuit board fabrication (PCB) industry. These dimensions are subsequently apportioned into the three stages of transformation that comprise the value-chain. It is our belief that this inductive approach to identifying the dimensions of flexibility will significantly improve the conceptual and descriptive understanding of the domain of flexibility.

2. Literature review

Flexibility is a broad concept; it applies to a range of disciplines and sub-disciplines, with its meaning varying from context to context. For example, economics incorporates flexibility in the theory of the firm as flatness of the average cost curve (Stigler, 1939), in the liquidity theory as the ability to switch positions (Jones and Ostroy, 1984), and in the theory of consumer choice as the reversibility of a decision (Koopmans, 1964). Management assimilates flexibility in the population ecology literature through ‘generalism’ and ‘specialization’ strategies (Singh and Lumsden, 1990), in the organizational evolution literature through ‘slack resource’ strategies (Cheng and Kesner, 1997), and in the organizational theory literature as ‘mechanistic’ versus ‘organic’ organizational structures (Burns and Stalker, 1961; Volberda, 1998).

Although we acknowledge that flexibility has diverse interpretations, we now narrow the remaining discussion to the manufacturing discipline. Manufacturing

flexibility itself has been approached from many different perspectives, and we recognize that no single paper should attempt to condense its content into a single theme. Accordingly, a selective review of the literature pertaining to the scope of this research is presented first. This is followed by a discussion of the reactive and proactive uses of flexibility. Finally, we describe a generic example of labor flexibility that challenges the themes promoted in the flexibility literature.

2.1. Antecedents for developing a flexibility framework

Our comprehensive search of the manufacturing flexibility literature revealed that a gamut of perceptions could be inferred from the use of the word ‘flexibility,’ suggesting that the term has diverse meanings for researchers. Supporting the belief advanced in earlier studies (Sethi and Sethi, 1990; Toni and Tonchia, 1998; Zhang et al., 2003), we found that not only do different researchers use assorted terms to refer to the same flexibility type, but they also use identical terms in a manner where their associated meanings do not agree. Shewchuk and Moodie (1997) attribute the existing confusion to “the fact that researchers have by-and-large defined flexibility types based upon a limited view of the manufacturing system, reflecting their own particular areas of interest and biases” (p. 261).

Typically, when classifying flexibility, researchers have developed frameworks that are divided into stages (sometimes referred to as ‘levels’ or ‘tiers’), with each stage consisting of associated dimensions. Our literature search revealed that there are conflicting proposals about the stages of flexibility, their dimensions are very different, and none of them provide a classifying criterion (for e.g., see Hyun and Ahn, 1992; Koste and Malhotra, 1999; Sethi and Sethi, 1990; Slack, 1988). Noting this weakness in the literature, Gerwin (1993) commented, “Most treatments of flexibility assume it is a multi-dimensional concept, but provide no theoretical basis for finding its relevant dimensions” (p. 398). He called for future research to provide an unifying theory of flexibility. More recently, other researchers (D’Souza and Williams, 2000; Toni and Tonchia, 1998; Volberda, 1998) have alluded to similar weakness in the flexibility literature.

Further complicating this issue, the previously defined stages of flexibility have been embedded in a hierarchical conceptualization, which purports the view that flexibility moves in one direction within an organization’s hierarchy, from lower level to higher

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