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Flexibility configurations: Empirical analysis of volume and product mix flexibility

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ABSTRACT

In this paper we address flexibility and investigate the relationship between volume and product mix flexibility. One view of flexibility is that of being a capability in itself; another view is that of flexibility as an enabler, providing the manufacturing system with properties on which other competitive capabilities are built. In this research, the latter view of flexibility is used, where flexibility acts as a second order competitive criterion. The aim is to differentiate between two dimensions of flexibility important to the manufacturing value chain, i.e., volume and product mix flexibility, and to investigate how different flexibility configurations are related to various manufacturing practices. A clustering research approach is used to identify groups of companies based on flexibility configurations. The groups are then analyzed with respect to characteristics and impact on operational performance. For the empirical investigation, we use empirical data from the high performance manufacturing (HPM) study, including three industries and seven countries—a total of 211 plants. We find that flexibility configurations based on high or low levels of volume and mix flexibility combinations show significant differences both in terms of operational performance, and in terms of emphasis put into different flexibility source factors.

1. Introduction

Increased competition, global markets, and more challenging customers are all ingredients of today's business environment and contributors to higher uncertainty and variability. Manufacturing flexibility has been proposed to handle or mitigate the effects of these challenges [1,2]. Manufacturing flexibility is an important element of a firm's operations strategy, as being one of the main competitive priorities commonly used [3]. This view makes flexibility a goal in itself. Another view of flexibility is as an enabler; a means for providing the capability to respond quickly to shifts in the market [4]. In this study we take the latter perspective, with manufacturing flexibility as an enabler that provides the manufacturing system with properties on which other capabilities are built.

Although manufacturing flexibility is recognized as important, the value of flexibility has been difficult to establish empirically. However, there are case studies concerned with the evaluation of flexibility using mathematical modeling, see [2,5,6]. Still, Dreyer and Grønhaug [7] claim that empirical research on manufacturing flexibility is still lagging. Then again, performance metrics such as overall profitability and return on assets are related to the company as a whole and thus distorted by other functions within the company. To better assess the actual impact from manufacturing flexibility on the performance of the manufacturing function, the use of operational performance have been proposed [8,9].

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While past research informs about how manufacturing firms can successfully achieve a certain type of flexibility, there are few insights for understanding how different types of flexibility can be simultaneously achieved within a manufacturing plant and its supply chain [10]. In a recent case study, Salvador et al. [10] found that a few approaches used to increase volume flexibility actually negatively affected mix flexibility and vice versa. They also observed that, to some extent, volume and mix flexibility may be achieved synergistically. They identified a need for large-scale empirical research. This paper fills this gap by providing an empirical study of the interrelationships among volume and product mix flexibility.

The purpose of this empirical study is threefold: (i) we aim to investigate how volume flexibility and product mix flexibility are interrelated. For flexibility configurations based on high or low levels of volume and product mix flexibility, we aim to (ii) analyze the impact on operational performance, and (iii) analyze the source factors that firms use to establish high levels of volume and/or mix flexibility. We link the flexibility source factors to the strategic flexibility approaches by Gerwin [1] for how to cope with uncertainty, i.e., proactive and adaptive approach. In doing so, we answer Gerwin's [1] call for applied flexibility research aimed at managerial application and problem-solving that makes academic operations management research more relevant and accessible to managers.

The paper is organized as follows. We first review the literature on manufacturing flexibility related to our purpose, before presenting our conceptual model. We then describe the research methodology and the empirical study. Finally, we present the results and discuss managerial and research implications.

2. Perspectives on flexibility

In this section, we review the related literature. General overviews and reviews of manufacturing and supply chain flexibility can be found in Sethi and Sethi [11], De Toni and Tonchia [12], D'Souza and Williams [13], and Stevenson and Spring [14]. Here we review literature on output flexibility, the impact on performance, flexibility source factors, and strategic flexibility approaches, before combining these in the research model.

2.1. Output flexibility

In recent years, flexibility has received much attention from both academics and practitioners as a source of competitive advantage. The competitive environment has seen a major transformation in the last decades, from the relative stability of the 1980s to today's intense global competition with, e.g., shorter product life cycles [15]. Flexibility is a complex, multi-dimensional concept and is defined on a metalevel as the ability to adapt to environmental change [16]. Upton [17] added "…with little penalty in time, effort, cost, or performance" bringing efficiency into the picture. We define those penalties in terms of cost, quality, and delivery performances. It is well established that flexibility can be viewed in many perspectives; the two most widely cited being volume flexibility and product mix flexibility [9,10,18–20]. For example, Chen et al. [18] stated that: "Depending upon the competitors' penetration, firms can be faced with drastic changes in product mix and/or volume. In the environment of volatile demand, firms' profitability lies in the extent to which they can neutralize the effects of these demand uncertainties. Consequently, firms with both volume flexibility and mix flexibility incorporated in their manufacturing systems can respond better to this aspect of environmental uncertainty". Further, D'Souza and Williams [13] defined four dimensions of manufacturing flexibility, and found that volume and variety are "mainly externally driven" towards meeting the needs of the market. Upton [21] viewed this as external flexibility, i.e., what the customer sees (capabilities). We therefore focus on volume and (product) mix flexibility in this study and refer to them as output flexibility types; cf. [22–24]. Volume flexibility is defined as the ability to change the level of output of a manufacturing process [1,13]. It demonstrates the competitive potential of the firm to increase production volume to meet rising demand and to keep inventory low as demand falls [1]. Product mix flexibility in general refers to the ability of the manufacturing system to cope with changes in the product mix [5]. Berry and Cooper [25] defined it as the ability to produce a broad range of products or variants with presumed low changeover costs.

2.2. Flexibility and performance

According to Lau [26], flexibility has become one of the most important factors in achieving a competitive advantage. However, in order to remain competitive achieving higher degrees of flexibility must not come with a loss of productivity and quality [27]. This was also recognized in the latter part of Upton's [21] definition of flexibility: "…without incurring high transition penalties or large changes in performance outcomes". Over the last two decades, several studies have provided evidence for the relationship between flexibility and performance in manufacturing. Swamidass and Newell [28] and Vickery et al. [29] found significant positive relationships between manufacturing flexibility and financial performance. Gupta and Somers [30] found significant positive relationships between manufacturing flexibility and growth performance, which was also found by Vickery et al. [29]. More specifically, Vickery et al. [31], Suarez et al. [32], and Jack and Raturi [33] have shown that volume flexibility has a positive impact on a firm's performance. On the other hand, Feigenbaum and Karnani [22] found no relationship between volume flexibility and return on assets. Kekre and Srinivasan [34] provided some empirical support for the benefits of mix flexibility by demonstrating that a broader product line is associated with higher market share and profitability. Zhang et al. [20] found evidence for the positive effects from mix flexibility on customer satisfaction, and Das [35] observed significant positive effects on manufacturing cost reduction and delivery performance. Thus, empirical testing of the impact of flexibility on operational performance is relatively sparse. There seems to be no