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Technical Note

Toward a taxonomy of manufacturing flexibility dimensions

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Abstract

Researchers agree on the importance of manufacturing flexibility but are somewhat divided on the dimensions of this important construct. This paper seeks to find a middle-ground by working toward a generally acceptable taxonomy of manufacturing flexibility dimensions. The authors build on extant literature and propose a theoretically grounded operationalization of the manufacturing flexibility construct. Operational measures of manufacturing flexibility dimensions are identified and tested on a sample of 240 manufacturing firms. Results indicate good support for the theorized taxonomy.

Keywords: Manufacturing; Flexibility; Measurement; Empirical research

1. Introduction

Academicians and practitioners agree that the pressures of global competition will continue to grow in the twenty-first century. Barring some differences in terminology, the consensus is that the major competitive arenas will be cost, quality, and responsiveness, where responsiveness refers to flexibility and speed (Olhager, 1993). Most managers agree that cost and quality will continue to be competitive arenas for a firm. However, they also note that these are not enough to compete effectively in the marketplace. Flexibility to respond appropriately to changes in the competitive environment will be essential if a firm is to succeed in this increasingly global marketplace. It is therefore incumbent on managers and researchers to strive for a better understanding of the flexibility construct.

The manufacturing flexibility construct is not as well understood as are the cost or quality constructs. We know that the cost of a product is a function of direct labor, direct materials, and allocated overhead. Consequently, most firms have a reasonably accurate understanding of the cost of producing their products. The quality of a product is specifically defined when the firm identifies the characteristics that define product quality in the mind of the customer. Firms measure those characteristics and compare the data with predetermined standards to assess the degree of conformance between the quality characteristics and the design specifications. Thus, one can conceivably determine whether a product has met a predetermined standard of quality.

Flexibility, on the other hand, is not determined quite so easily. Most researchers in the area of manufacturing flexibility agree on a workable defini-

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tion of manufacturing flexibility. However, we notice significant variation in perspectives when we try to break down manufacturing flexibility into its dimensions, elements, and measures.

1.1. Objectives of the study

Gerwin notes that, ''operationalizing flexibility is ... the single most important research priority'' (1993, p. 405) for researchers in the area of manufacturing flexibility. However, only a few studies have operationalized this constructs, and even fewer studies have attempted to validate/refine such operationalizations based on empirical evidence. The objective of this paper is to develop a theoretically-grounded and empirically-tested operationalization of the manufacturing flexibility construct. The development builds on extant literature and results in a set of dimensions and elements of the manufacturing flexibility construct. We use data collected from 264 manufacturing firms to assess the validity of our operationalization.

2. Manufacturing flexibility

Most studies on manufacturing flexibility provide implicitly or explicitly stated definitions of the manufacturing flexibility construct. Some representative definitions are presented below.

- The ability to change or react with few penalties in time, effort, cost, or performance (Upton, 1994).
- The ability to implement changes in the internal operating environment in a timely manner at a reasonable cost in response to changes in market conditions (Watts et al., 1993).
- In the short run, flexibility means the ability to adapt to changing conditions using the existing set and amount of resources. In the long run, it measures the ability to introduce new products, new resources and production methods, and to integrate these into the existing production system (Olhager, 1993).
- The ability to respond effectively to changing circumstances (Gerwin, 1987; Gupta and Gupta, 1991).
- The capacity of a manufacturing system to adapt successfully to changing environmental conditions and process requirements. It refers to the ability of the production system to cope with the instability induced by the environment (Swamidass, 1988).

There is considerable commonality in these definitions of manufacturing flexibility. Specifically, they all describe manufacturing flexibility as the ability of the manufacturing function to react to changes in its environment. In addition, most of the definitions make some reference to the time such adjustments might take, the cost of the adjustments, and the effort required. This is consistent with Upton's (1995) observation that each dimension of manufacturing flexibility can be represented by two elements: the *range* of adjustment on the dimension, and the *mobility* of the adjustment on the dimension. We will elaborate on these elements later. For now, we present a working definition of manufacturing flexibility that encompasses the components common to most definitions found in the literature: Manufacturing flexibility is a multidimensional construct that represents the ability of the manufacturing function, to make adjustments needed to react to environmental changes without significant sacrifices to firm performance. Such adjustments are typically in the range of outputs and/or the mobility to respond to change.

2.1. Dimensions of manufacturing flexibility

There is general agreement among researchers that manufacturing flexibility is a multidimensional concept. However, they differ on what the underlying dimensions should be. Sethi and Sethi (1990) suggest 11 dimensions of manufacturing flexibility, Gupta and Somers (1996) identify nine, whereas Gerwin's (1993) taxonomy consists of seven dimensions. Some dimensions identified by researchers are strategic in nature. Examples include diversification of the product line, product innovation, responsiveness to customer specifications, and strategic adaptability. Others are tactical in nature. Examples might include accommodating variations or shortages in components or raw materials and adjusting job routing to bypass a disabled machine or process. Watts et al. (1993) address this hierarchical nature of manufacturing flexibility dimensions when they note that some dimensions are ''primary,'' whereas others are ''secondary.'' They note that the secondary dimensions may be components subsumed under the primary dimensions. In this paper, the unit of analysis