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Conceptual Note

A review of empirical research on manufacturing flexibility

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Abstract

Manufacturing flexibility is widely recognized as a critical component to achieving a competitive advantage in the marketplace. A comprehensive look at the empirical research pertaining to manufacturing flexibility highlights the very fragmented nature of this body of work. We present a comprehensive contingency-based framework for examining the content related issues involving the relationships and variables included in past studies. We also examine several important research design/methodology issues (e.g., sampling, data collection and measurement) and propose solutions to some identified problems.

Keywords: Manufacturing flexibility; Empirical research; Measurement and methodology

1. Introduction

In today's fast paced environment, characterized by short product life cycles and increasing product variety, manufacturing flexibility is emerging as a key competitive weapon. Manufacturing flexibility reflects the ability of firms to respond to changes in their customers' needs, as well as to unanticipated changes stemming from competitive pressures. Companies are addressing these types of competitive pressures through a variety of improvement programs involving manufacturing flexibility, such as just-in-time manufacturing, mass customization techniques, time-based methods of competition, and agile manufacturing. Since Hayes and Wheelwright (1984) first advocated that manufacturing flexibility be one of the primary dimensions of the competitive strategy of a business, there has been a substantial growth in the amount of research on this topic. Although there has been a great deal of progress towards the enhancement of the knowledge base concerning manufacturing flexibility, a close examination of past studies reveals the fragmented nature of the overall body of literature.

This paper has two main purposes. First, we will synthesize the growing body of empirical research regarding content-related issues and identify possible avenues for future research in the area of manufacturing flexibility. We center our discussion around a contingency framework that highlights the compli-

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cated interrelationships that surround manufacturing flexibility. This framework, which identifies four exogenous variables (strategy, organizational structure, environmental uncertainty, and technology) that moderate the relationship between manufacturing flexibility and performance, is used to structure our review of previous studies and to suggest future research directions.

Second, we examine several important methodological issues regarding manufacturing flexibility research. An examination of past studies indicates several repeated methodological problems with regard to measurement validity and reliability, along with problems involving general design issues. In order to strengthen the validity and generalizability of the findings of future studies, we present several solutions to these methodological and design pitfalls.

2. Content related issues based on past research

The term manufacturing flexibility does not refer to a single variable, rather manufacturing flexibility refers to a general class of variables. One of the most widely recognized typologies for classifying the different dimensions of manufacturing flexibility was developed by Browne et al. (1984). In their original framework, they identified eight distinct types of manufacturing flexibility. Sethi and Sethi (1990) enhanced this framework to include 11 distinct dimensions, and as part of this review, we have identified four additional flexibility dimensions: automation, labor, new design, and delivery. The definition and origin for each of the flexibility dimensions is contained in Table 1. These will be referenced later as we discuss the published empirical manufacturing flexibility research.

Although research in the area of manufacturing flexibility has progressed in the last several years, our general understanding of the complex relationships involving manufacturing flexibility remains fragmented. In order to address this issue, we critically examine previous models and propose a more comprehensive model of our own, one that builds on past research and ties together recent developments in the field.

2.1. Previous manufacturing flexibility frameworks

Previous models suggest that manufacturing flexibility is dependent on the nature of a firm's internal operations and external environment (e.g., Gerwin, 1987; Slack, 1988; Parthasarthy and Sethi, 1993). A close examination of past studies reveals that four

Table 1
Definitions of flexibility dimensions

Machine[a]	range of operations that a piece of equipment can perform without incurring a major setup
Material handling[a]	capabilities of a material handling process to move different parts throughout the manufacturing system
Operations[a]	number of alternative processes or ways in which a part can be produced within the system
Automation[b]	extent to which flexibility is housed in the automation (computerization) of manufacturing technologies
Labor[c]	range of tasks that an operator can perform within the manufacturing system
Process[a]	number of different parts that can be produced without incurring a major setup
Routing[a]	number of alternative paths a part can take through the system in order to be completed
Product[a]	time it takes to add or substitute new parts into the system
New design[d]	speed at which products can be designed and introduced into the system
Delivery[c]	ability of the system to respond to changes in delivery requests
Volume[a]	range of output levels that a firm can economically produce products
Expansion[a]	ease at which capacity may be added to the system
Program[a]	length of time the system can operate unattended
Production[a]	range of products the system can produce without adding new equipment
Market[a]	ability of the manufacturing system to adapt to changes in the market environment

[a] Definitions adapted from Sethi and Sethi (1990) and Gupta and Somers (1992).
[b] Definitions adapted from Parthasarthy and Sethi (1993).
[c] Definitions adapted from Slack (1983).
[d] Definitions adapted from Dixon (1990) and Suarez et al. (1995, 1996).