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Process-technology fit and its implications for manufacturing performance

Ajay Das [a,*], Ram Narasimhan [b]

[a] Department of Management, Zicklin School of Business, Baruch College, City University of New York, Box F-1813, 17 Lexington Avenue, New York, NY 10010, USA

[b] Department of Marketing and Supply Chain Management, Eli Broad Graduate School of Business, Michigan State University, East Lansing, MI 48824, USA

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Abstract

This study investigates the issue of fit between process environment and advanced manufacturing technology, and its impact on manufacturing and business performance. We find that different process environments tend to align advanced manufacturing technology investments in distinct profiles, which are associated with superior performance. Deviations from these 'ideal' profiles are shown to have a negative impact on manufacturing performance. The findings also suggest that firms are not fully exploiting the potential afforded by AMT investments to compete in off-diagonal positions in the Hayes–Wheelwright framework. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

The concept of 'fit' or alignment has been discussed and investigated in many disciplines. The business strategy literature has examined fit between environment and strategy in different contexts and found that lack of fit has significant effects on performance (Hofer, 1975; Hambrick, 1980; Venkatraman and Prescott, 1990). The supply chain management literature has studied fit as a function of alignment between sourcing practices and product life cycle (PLC) stage (Birou et al., 1998). Similarly, frameworks linking process type to market characteristics and PLC have been developed in the operations management literature (Hayes and Wheelwright, 1979; Hill, 1994). While addressing different issues, these investigations have all stressed the link between the extent of alignment achieved by a firm and its performance outcomes.

Hayes and Wheelwright (1979) in their seminal paper, suggested that superior manufacturing performance is contingent on the degree of alignment between the process environment and the volume–variety characteristics of the market. Different process environments would, therefore, emphasize different goals. A jobshop would likely compete on the basis of customization and flexibility, and a flow shop on delivery and cost performance. Accordingly, investments in machinery and personnel can be expected to differ across process environments.

* Corresponding author. Tel.: +1-212-802-6920; fax: +1-212-802-6873.
E-mail address: ajay_das@baruch.cuny.edu (A. Das).

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As is well known, jobshops utilize general-purpose machines and multi-skilled workforce, and assembly lines use dedicated equipment with less-skilled labor. Hayes and Wheelwright (1979) argue that firms not aligned in terms of market, process technology and labor choices, i.e. firms not 'on the diagonal' would suffer performance setbacks. However, recent advances in technology have enabled firms to operate in off-diagonal positions without the performance penalties predicted by the Hayes and Wheelwright (1979) framework. These developments have heightened research interest in the role and use of advanced manufacturing technologies and practices, in different process environments. Safizadeh et al. (1996) found that companies in line flow industries are successfully operating in "off-diagonal" positions in Hayes and Wheelwright's (1979) framework, meeting customization requirements by deploying flexible manufacturing systems and practices. Similarly, there are examples of firms using cellular manufacturing layouts with small production lots in a jobshop environment to achieve efficiencies comparable to line-flow operations (Markland et al., 1998). Computer-aided design and manufacturing techniques are being employed to reduce product development and production cycle times.

A growing body of evidence thus suggests that off-diagonal positions in Hayes and Wheelwright's (1979) framework are indeed viable through the use of advanced manufacturing technologies and practices. However, these studies have not attempted to develop a prescriptive model to address the question: are there ideal configurations of advanced manufacturing technology investments that result in superior manufacturing performance for a given process environment? The answer to this question will help firms in two ways: enable them to evaluate and address gaps in their advanced technology investment patterns vis-à-vis an 'ideal' configuration; and determine whether advanced technology would facilitate a move to an "off-diagonal" position, to pursue what might be non-traditional competitive goals for their process environment. This paper attempts to develop an answer to this central research question of strategic importance.

The next section discusses past research on manufacturing process and manufacturing technology. Based on the literature, a conceptual model is developed leading to a set of propositions related to the central research question of interest. The succeeding sections describe scale development, data collection and analysis, and statistical testing of the propositions. The paper concludes with a discussion of the findings and their implications for manufacturing strategy theory and practice.

2. Overview of the literature

Choosing a manufacturing process type is a strategic decision in operations management, with attendant implications for performance. The literature on process choice presents a strong rationale for aligning process type with PLC stage and product/market characteristics (Hayes and Wheelwright, 1979; Hill, 1994). High variety, low volume market environments would demand a process capable of small production run sizes and high set-up frequencies, with relatively low set-up costs. A jobshop would address these needs allowing a firm to compete on flexibility, customization and new product development capabilities. Low variety, high volume market environments would require extended production runs, and usually entail relatively high set-up costs. An assembly line best fits this environment, where cost and quality are primary strategic capabilities. Empirical evidence in the literature supports these perspectives. Ward et al. (1992) found that "typical producers" align process choice decisions with PLC stages. Safizadeh et al. (1996) allude to the strategic importance of alignment between process choice and a firm's competitive priority.

Firms pursue competitive goals by adopting what they deem to be appropriate technology initiatives. New technologies in the form of programmable machines, flexible manufacturing systems, computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM) practice innovations such as worker teams and cellular manufacturing have allowed high volume producers to offer more variety, and created opportunities for efficient small lot manufacturing for these producers. Advanced manufacturing technologies have also been adopted by jobshops to reduce costs. Computer numerical controlled (CNC) machines, CAD, CAM, and operator teams are widely used across different