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The impact of new product & operations technological practices on organization structure

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ABSTRACT

This study chooses two product technological elements (customized design and modular design) and two operations technological elements (process automation and process flexibility) from among a number of best practices to study their impact on organization structure, including centralization, specialization, formalization, managerial level and span of control. The aim is to understand more about the interaction between new technology practices (as mass customization enablers) and organization structure, and how culture affects them.

We distributed a questionnaire and received 548 usable responses from MBA and Executive MBA alumni in China. This study found that the introduction of new technological practices can lead to decentralization, less specialization, less formalization and lower span of chief managers at the early stages of implementation. Following a U-shaped curve, the impact of new technological practices would reverse course. The Idealist perspective is supported at the prophase and the Marxist perspective is supported at the anaphase of implementation. This study provides empirical evidence for both Technical Determinism and Social Shaping of Technology (SST).

1. Introduction

Companies in general, whether in the manufacturing or service sector, face an increasingly uncertain external environment, characterized by rigorous global competition and unyielding customer demands.

Production and operations management areas, in response to these challenges, deploy many best practices, including TQM (total quality management), LP (lean production), WCM (world class manufacturing), HPM (high performance manufacturing), AMT (advanced manufacturing technology), FMS (flexible manufacturing systems), MC (mass customization), and SCM (supply chain management). Almost all of these best practices are used as strategic weapons by company managers. But there are still no definitive results for the relationship of best practices to organization structure and performance (Dean et al., 1992; Koc and Bozdag, 2009; Gunasekaran and Ngai, 2012).

When scholars first began to research best practices, organization structure and culture were mentioned as important factors for implementation (Pine, 1993; Schroeder and Flynn, 2001; Fogliatto et al., 2012), but later studies have shown mixed results. There is considerable confusion between two alternative patterns: the Marxist perspective suggests that best practices may lead to centralized decision-making and high levels of formalization. The Idealist perspective suggests that best practices may lead to decentralized decision-making and limited formalization (Dean et al., 1992; Ghani et al., 2002). Which one is closer to social reality? Two decades have passed since the research on advanced manufacturing technology and organization structure has found support for both the Marxist and the Idealist viewpoints (Dean et al., 1992).

Until now, no single best practice is sufficiently well-defined in the academic community. Both technological elements and organizational elements may co-exist in a single best practice (Scott, 1998). And generally, technological elements are considered as the main driver of best practices. Examples of technological elements are: rebuilding manufacturing engineering; information systems and technology management; innovation and technology; design for manufacturing and modular product design; process flexibility; potentially independent numerical control machine tool and automated material-handling systems (Schroeder and Flynn, 2001; Hallgren and Olhager, 2009; Liao et al., 2013). But many

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other factors mentioned in connection with best practices can be regarded as organizational elements or managerial tools. These include worker participation manufacturing strategy and human resources (Schroeder and Flynn, 2001; de Blok et al., 2012); top management commitment and employee empowerment. Some empirical studies about the relationship of best practice to organization structure could lead to confusion (Dean et al., 1992; Koc and Bozdag, 2009).

This study therefore has collected data in China to study the impact of the technological elements of best practices on organization structure to help fill the research gap. We chose four of the measurements listed above to represent the new technological practices in this study: customized design, modular design, process automation and process flexibility. In the field of product technology, customized design (or customer-involved design) and modular design are marked phenomena. Process automation and process flexibility figure prominently in the area of operations technology.

2. Literature review

The literature on the relationship of best practices, including technology, to organization structure, falls into two categories: operations technology and product technology.

2.1. Operations technology and organization structure

Research on the relationship of technology and structure, which began with Woodward's investigation of the "fit" between technology and organization structure. As the scope of research extended from manufacturing to service companies, scholars found that operations technology affects only those structural variables immediately impacted by the workflow (at the operating subsystem level), but it is not obviously related to the wider administrative and structural level (the strategic level) (Hickson et al., 1969). These results are supported by a national study and replications by the Aston Group at Aston University in England. Organization size is more closely associated with the elements of organization structure in general, whereas technological variables are associated with structure only in certain respects.

The technology-structure relationship is an important topic in cross-culture comparative research (Delmestri and Walgenbach, 2005). A study to explore differences in organization structure between Japanese and American companies surveyed 55 American and 51 Japanese manufacturing plants. It found less specialization, more elaborate hierarchies and greater centralization but less *de facto* centralization in the Japanese organizations compared to the American companies. The relationship between technology and structure is stronger in American companies than in Japanese companies because of cultural factors (Lincoln et al., 1986).

2.2. Product technology and organization structure

Research on mass customization in the 1990s concentrated on product modularity (Pine, 1993; Baldwin and Clark, 2000), and product technology thus became one of the factors affecting organization structure and managerial affairs. Sosa et al. (2004) integrate product architecture and organization structure perspectives to study how design interfaces in the product architecture map with communication patterns in the organization. They explain the misalignment of product architecture and organization structure by citing two different causes: known design interfaces not addressed by team interactions and observed team interactions not predicted by design interfaces (Sosa et al., 2004).

Vickery's research examines the relationship between product customization (measured by made-to-order and organization structure (formal control, centralization, layers, and spans of control), controlling for enterprise size and environmental uncertainty. The researchers found that product customization correlates with more formal control, fewer layers, and narrower spans of control (Vickery et al., 1999).

There is considerable literature on product and organizational modularity (Baldwin and Clark, 2000; Sanchez and Mahoney, 1996). Under the principle of nearly decomposable systems, embedded coordination mechanisms based on modular product architecture connotes hierarchical coordination without the need to continually exercise authority. Thus, the organization structure can also be cut into independent blocks, with the information structures between blocks providing the 'glue' that holds together the loosely coupled parts of a modular organization (Sanchez and Mahoney, 1996).

Substantial research also exists on the relationship between product architecture modularity and firm relations, as well as supply chain and industry structure. An efficient implementation of modular product architecture needs an equally efficient modular organization (Sanchez and Mahoney, 1996), but firms transferring to technological modularity and organizational modularity must follow a path that may differ for each industry. Generally, these paths are not synchronous. For example, when the European Civil Aircraft established technological modularity, its organizational modularity was still in the process of emerging. Another example from the European auto industry shows an established organizational modularity combined with a slowly emerging technological modularity (Frigant and Talbot, 2005).

Highly modular designs require firms to divide their development and production organizations into specialized groups with a narrow focus. The design and production of a modular component can be assigned to a separate entity. Modular architecture may require strong systems engineering and planning skills, while integral architecture may require strong coordination and integration skills (Ulrich, 1995).

Two contradictory views on the relationship of technology and organization structure exist. Most of the research mentioned above belongs to a group known as Technical Determinism. This approach attempts to confirm that technology can predict most dimensions of organization structure. Social shaping of technology (SST), in contrast to Technical Determinism, contends that technological development does not represent an inexorable logic of Technical Determinism or economic efficiency but, instead, some combination of what is technically possible and socially acceptable, even socially constructed (Scott, 1998). In the automated system design of machine tools, the numerical control approach won out over record-playback approaches because the numerical control approach put control in the hands of programmers and managers rather than machine operators on the shop floor. Powerful interests such as US Air Force, aerospace contractors, and the engineering community especially like the concept of Social Shaping of Technology. In researching implementation of advanced manufacturing technology in a developing country, we find that traditional organization structures indicate slow adoption. Technological change has almost no effect on organization structure when advanced manufacturing technology is introduced in a routine or low-key fashion (Ghani et al., 2002).

3. Model delineation

This study explores the impacts of four groups of new technological practices (as mass customization enablers) on five dimensions of organization structure based on the literature. The model