



## Operational flexibility: Review and meta-analysis



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### ABSTRACT

Several streams of literature increasingly consider flexibility at all levels and functions of the manufacturing and supply chain. This paper reviews flexibility studies in operations management, supply chain management, and marketing. It considers the definitions, dimensions, drivers, sources, and performance outcomes of operational flexibility. In doing so, it offers a meta-analysis of 57 empirical studies that examines the magnitudes of the sources and performance outcomes of operational flexibility. It discusses not only research directions that arise from the review and meta-analysis, but also the managerial implications of a broader contingency model of operational flexibility.

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## 1. Introduction

For operations managers who face benevolent environments that do not entail major changes, rigid responses may be the best course of action. For others, the economic globalization, development of information technology and diversity of customer requirements cause many enterprises to face highly volatile and uncertain environments arising from short product life cycles and frequent and unpredictable changes in demand. For such enterprises, flexibility has increasingly become a core strategic competency. From an analytic standpoint, the concept of a flexible supply chain constitutes an open system, consisting of not only operational flexibility, but also its drivers, its sources, as well as its performance outcomes. While such an open systems view of operational flexibility has helped make the phenomenon more visible, at the same time, it has often resulted in a confusion of levels of analysis and levels of managerial action. In particular, it can potentially confuse organizational structure, operational process, and intermediate (e.g., non-financial) performance outcomes. This paper will carefully consider these problems and attempt to offer some analytic and potentially managerially useful solutions.

The literature does not contain a systematic review of factors associated with operational flexibility and the relationships among these. Although several models outline some key aspects of flexibility (e.g., Duclos et al., 2003; Lummus et al., 2003, 2005;

Kumar et al., 2006; Stevenson and Spring, 2007; Thomé et al., 2014), a comprehensive review and analysis of this important concept can help clarify some of the confusion and organize knowledge so as to improve the understanding of this concept. This paper develops both a qualitative literature review and a quantitative meta-analysis in order to explicate the structure and process of operational flexibility, including its dimensions, its driving factors, its sources, and its consequences. In addition, this study examines how different structures, strategies, and behavioral processes that underlie flexible operations might fare across commonly recurring settings (Hambrick, 1983). In doing so, it develops a contingency theory which, in its simplest form, claims that no universal set of strategies is optimal for all firms and that, therefore, strategies need to be designed for specific environmental contexts (Donaldson, 2001).

## 2. Theoretical framework

Operational flexibility is a topic that crosses disciplinary boundaries. Thus, according to the journal citation ranking of manufacturing flexibility and supply chain flexibility (see review by Seebacher and Winkler (2013)), this review covers studies published in operation management journals including *International Journal of Production Research*, *International Journal of Operations & Production Management*, *Journal of Operations Management*, *Management Science*, *International Journal of Production Economics*, *European Journal of Operational Research*, *International Journal of Physical Distribution & Logistics Management*, *Journal of Business Logistics*, *Decision Sciences*, *International Journal of Logistics Management*,

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*Production and Operations Management, Operations Research, Supply Chain Management: An International Journal, and Journal of Supply Chain Management*; in marketing journals including *Journal of Marketing, Journal of Marketing Research, Journal of Business Research, Journal of the Academy of Marketing Science, Industrial Marketing Management, and Journal of Business & Industrial Marketing*; as well as in systems and information management journals including *Global Journal of Flexible Systems Management, Industrial Management & Data Systems, Journal of Manufacturing Technology Management, Integrated Manufacturing Systems, Journal of Enterprise Information Management, and International Journal of Flexible Manufacturing Systems*. Key terms searched in the title, abstract or keywords of these journals include, for example, flexibility, manufacturing flexibility, supply chain flexibility, value chain flexibility/agility, flexible supply chain, logistics flexibility, and supply flexibility. The time range was not constrained, so the latest paper included in the literature pool was published in April 2015 when we finished the revision. A total of 371 papers were retrieved and finally included in the reviewing database.

By treating flexible operations management as an open system that includes not only flexibility itself, but also its drivers, its sources and its performance outcomes, it is possible to organize studies of flexibility in operations management, supply chain management and marketing along these dimensions. Table 1 groups these studies into two categories: studies of manufacturing flexibility and studies of supply chain flexibility. Within each of these categories it is possible to then use the following framework to code the key findings: (a) definition and dimensions of flexibility including its various uses as a strategy or strategic choice, as a capability, as a relation norm, as a tier of a hierarchical system, as a tier of a cross-functional system, and as an output of a mixed system; (b) drivers of flexibility including uncertainty and heterogeneity; (c) sources of flexibility including both intra-organizational and inter-organizational aspects; and (d) outcomes of flexibility including firm orientation and supply chain orientation respectively.

### 2.1. Definitions and dimensions of flexibility

In the literature, definitions of flexibility are, to put it simply, far too diverse. In the context of manufacturing systems, flexibility usually refers to the ability of a system to cope with changes (Gupta and Buzacott, 1989). However, this definition, in itself, does not explain what it means “to cope” with changes. Several researchers imply do try to elaborate on the meaning of “coping” from the perspective of a manufacturer’s capability. Kim (1991) distinguishes two meanings of the term manufacturing flexibility: *strategic* manufacturing flexibility (which, in particular, is not likely to be compatible with a strategy of low cost manufacturing) and *operational* manufacturing flexibility which is the capacity of a manufacturer to react to changing environments as well as to bring about changes in manufacturing operations. A definition of manufacturing flexibility that combines these two aspects might be “the ability to change or react with little penalty in time, effort, cost or performance” (Upton, 1994). Upton (1994) expanded on the original two elements of flexibility: range and response (Slack, 1987; Swamidass and Newell, 1987). Upton (1994) also designed a framework for analyzing manufacturing flexibility including its dimensions, its time horizon and its elements. Later empirical studies have applied this framework to measure manufacturing flexibility (D’Souza and Williams, 2000; Narasimhan and Das, 2000).

Even though practitioners widely view manufacturing flexibility as a multi-dimensional concept within the manufacturing function, researchers have yet to reach an agreement on its dimensions. At least 50 different terms for various types of flexibility arise in the manufacturing research literature (Sethi and Sethi, 1990). These terms generally refer to substantive

domain dimensions which, to name a few, could include machine flexibility, labor flexibility, material handling flexibility, routing flexibility, operation flexibility, expansion flexibility, volume flexibility, mix flexibility (the ability to produce a number of different products at the same point in time) (Gerwin, 1987), product flexibility, new product flexibility, and modification flexibility (Browne et al., 1984; Gerwin, 1987; Gupta and Goyal, 1989; Koste and Malhotra, 1999). These dimensions have proliferated over time. To create a more parsimonious depiction, it is very reasonable to array these dimensions along several more general hierarchies. Early typologies distinguished between basic, system, and aggregate (Sethi and Sethi, 1990), or operational, tactical, and strategic (Upton, 1994), but a more comprehensive analysis depicts five tiers extending from an operational level to a strategic level (Koste and Malhotra, 1999; Patel et al., 2012). In this hierarchy, flexibility could arise at any tier.

Given increasing cross-functional and cross-company efforts to broadly increase flexibility, a focus limited to *manufacturing* flexibility might be insufficient to deal with more complex and turbulent environments (Duclos et al., 2003; Kumar et al., 2006; Lummus et al., 2003; Sánchez and Pérez, 2005). Environmental complexity and turbulence demand a broader concept of *supply chain* flexibility that extends beyond the manufacturing enterprise. Such a concept of supply chain flexibility extends beyond the internal flexibility of a single firm (Lummus et al., 2003). Thus, such a concept of supply chain flexibility encompasses those flexibility dimensions that directly affect a firm’s customers and that are the shared responsibility of two or more functions along the supply chain, either functions internal to the firm such as marketing or manufacturing or functions external to the firm such as those involving upstream suppliers or downstream members of a distribution channel (Vickery et al., 1999). Furthermore, a complete definition of supply chain flexibility components should include the flexibility dimensions required by all of the participants in the supply chain in order to successfully meet customer demand (Duclos et al., 2003). Previous studies have identified several dimensions of supply chain flexibility, and most add a few new dimensions to those originally related to manufacturing flexibility.

Based on the earlier framework of Sethi and Sethi (1990), Sánchez and Pérez (2005) proposed three hierarchies of supply chain flexibility dimensions: basic shop-floor (product, volume), system-company (delivery, trans-shipment, postponement), and aggregate-chain (launch, sourcing, response, access). The nine dimensions are either internal or external functions along the supply chain. Although previous research on manufacturing flexibility may be more concerned with internal dimensions, supply chain flexibility includes both internal and external aspects but clearly tends to put more emphasis on the external.

Departing from a purely vertical view, there is a new horizontal (chain) system view that tries to capture each process along the supply chain including sourcing flexibility, manufacturing flexibility, and delivery flexibility (Fantazy et al., 2009; Jin et al., 2014; Kumar et al., 2006; Moon et al., 2012; Prater et al., 2001; Pujawan, 2004; Swafford et al., 2006; Tipu and Fantazy, 2014). Sawhney (2006) also use a simpler typology including input flexibility, process flexibility, and output flexibility.

However, researchers generally appear to support the idea of viewing operational flexibility as an output of a system including both its vertical and horizontal dimensions (Duclos et al., 2003; Stevenson and Spring, 2007; Zhang et al., 2002). Some add specific components to this system such as spanning flexibility (Zhang et al., 2002), organizational flexibility, and information systems flexibility (Duclos et al., 2003; Golden and Powell, 1999; Stevenson and Spring, 2007). Buyer–seller research develops another related construct, relationship flexibility, as one relational norm (Boyle et al., 1992; Han et al., 2014; Heide and John, 1992; Ivens, 2005; Richey et al., 2012). When introduced into the operations management literature (Johnston et

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