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The process management triangle: An empirical investigation of process trade-offs

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Abstract

Advancing theory and understanding of process management issues continues to be a central concern for operations management research and practice. While an insightful body of knowledge – based primarily on studies at the process-level – exists on the management of capacity and inventory, the dynamism characterizing most operating and competitive systems poses an ongoing challenge for managers having to mitigate the impact of variability across different levels of operating systems (e.g., production processes, facilities, and supply chains). This paper builds on a conceptual framework, derived from queuing theory and termed the ''process management triangle'', to explore the extent to which fundamental trade-offs between capacity utilization, variability and inventory (CVI) generalize to complex operations and business systems. To do so, empirical analyses utilizing comparatively unique data for the study of these process management issues – and collected from two distinct, vastly different levels of analysis – are presented. First, a simulation-based facility-level analysis using teaching case study data is presented. Second, an industry-level analysis employing archival economic data spanning three multi-year periods is considered. Collectively, these empirical analyses provide exploratory support for the generalization and extension of analytical insights on CVI trade-offs to both complex operations and business systems, although with decreasing explanatory power. The implications of these studies for furthering process management theory and understanding are framed around additional research propositions intended to guide future investigation of CVI trade-offs.

Keywords: Process management; Operating trade-offs; Variability; Manufacturing performance; Business systems

1. Introduction

Process management involves the understanding, design, and improvement of processes, and is of central interest to much of the field of operations management (OM). Theory and understanding of process-related issues like capacity utilization and inventory – based primarily on normative, optimization-based studies (Pannirselvam et al., 1999; Silver, 2004) – have advanced considerably, and insights generated from this research have informed and improved practice in both manufacturing and services. However, the complexity and dynamism characterizing operating and competitive environments continues to present challenges for (1) researchers examining these process-related issues for operating systems that span from individual production processes to complex supply chain networks, and (2)

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managers having to mitigate the impact of uncertainties on such systems. For example, in the event of a pandemic outbreak, many hospital executives adhering to just-in-time policies that boost efficiencies are now considering adopting a just-in-case approach to stockpiling critical products (e.g., face masks, syringes, vaccines) given anticipated supply chain capacity and inventory shortages for these products (Wysocki and Lueck, 2006).

Rudimentary process-level insights to this type of management problem are readily available. For example, a consultant report by Strategos (2006), entitled ''Capacity, Inventory, Variability and Manufacturing Strategy'' presents a simulation model of a simple production line intended to illustrate the ''vague and counter-intuitive'' way that capacity utilization, inventory and variability are related within a factory. While primarily of interest to managers desiring better intuition and insights on the inherent trade-offs required in managing these process-related issues, this report – along with the pandemic example offered earlier – serves to highlight the continued relevance and urgency for greater managerial understanding of process management fundamentals. Indeed, as managerial practice continues to struggle with having to identify clear pathways for operational improvement, further research is needed to link theoretical work in process management with practical diagnosis and improvement decision making (Chopra et al., 2004; cf. Little, 2004).

The objective of this research is to offer conceptually, and support empirically, a generalization and extension of the fundamental process management trade-offs heuristic between capacity utilization, variability, and inventory (cf. Lovejoy, 1998; Schmidt, 2005). Rigorous generalizations and extensions are critical to the theory-building process (Handfield and Melnyk, 1998). As such, our research contribution to process management theory and understanding is threefold. First, we conceptually generalize to more complex operating and business systems what has been derived previously through the analytic modeling of queues at the process-level (e.g., Hopp and Spearman, 2001), namely the general heuristic of capacity utilization–variability–inventory (CVI) trade-offs for process management. Our generalization results in the offering of two research propositions which, to the best of our knowledge, have remained unexamined in the process management literature.

Second, through an analysis of data collected from distinct, vastly different levels of analysis (i.e., facility-level and industry-level), we find exploratory empirical support for the broad application of CVI trade-offs for both complex operations and business systems. We empirically examine both teaching case study facility-level data and industry-level archival data, both constituting comparatively unique data sources for the study of CVI trade-offs.

Third, our empirical findings extend current modeling-based understanding of the trade-offs heuristic; hence, this research contributes to the advancement of process management theory and understanding (Handfield and Melnyk, 1998; Swamidass, 1991). We provide a number of meaningful, and novel, research and managerial insights for managing variability reduction for ongoing or improved process management performance. This underpins the paper's development of four additional research propositions offered to motivate future empirical investigation in process management.

The remainder of this paper is organized as follows. In Section 2 we offer a literature-based synthesis of fundamentals and the related issues of trade-offs and variability, followed by our research propositions. In Section 3 we describe our research methodology strategy, which is based upon McGrath's (1982) ''three-horned dilemma'' and involves the examination of process-management empirical data collected at the facility-level and industry-level. Research results are presented in Section 4. In Section 5 we present a discussion of our findings in order to generalize the CVI tradeoffs to other operating systems, and offer extensions of the trade-off heuristic in the form of additional research propositions to direct future process management research, before concluding.

2. Process management: trade-offs, variability and research propositions

A critical challenge in further developing process management knowledge both descriptively and prescriptively is the inherent complexity and dynamism of most operational settings (Buffa, 1980; Corbett and Van Wassenhove, 1993). Consider the general manufacturing context, where the challenges and trade-offs facing managers were accurately expressed by Skinner (1966, p. 140) and still remain true today:

> ''The corporation now demands a great deal more of the production manager. The assignment becomes—'Make an increasing variety of products, on shorter lead times with smaller runs, but with flawless quality. Improve our return on investment by automating and introducing new technology in processes and materials so that we can cut prices to meet local and foreign competition. Mechanize—but keep your