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Performance effects of using an ERP system for manufacturing planning and control under dynamic market requirements

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ABSTRACT

Enterprise resource planning (ERP) systems have a controversial reputation. Critics say that even if ERP systems may be beneficial for organizations operating in stable conditions, they are surely detrimental to organizations that face dynamic market requirements. This is because ERP systems are said to impose such procedures and constraints on organizations that make business processes inflexible to change. In contrast, proponents argue that the information-processing capabilities of ERP systems are crucial for organizations that face dynamic market requirements and also that the criticized procedures and constraints actually support process reengineering. These two contradictory arguments are often found in practitioner literature, but both of them can also be supported by management theory. The central tenets of the Organic Theory of organization design imply that ERP systems should be detrimental when market requirements change frequently, whereas the principles of Rigid Flexibility Theory suggest that they should be advantageous. In this study, we use cross-sectional data from 151 manufacturing plants to determine which argument is more applicable in the context of manufacturing planning and control. The results strongly favor the use of ERP systems under dynamic market requirements. To facilitate the reconciliation of the two contradictory arguments, we discuss how the results may have been influenced by two contextual factors: the predominantly technical nature of the studied organizational system and the tight interdependence of the studied activities.

1. Introduction

Enterprise resource planning (ERP) systems attracted considerable attention in the business world at the turn of the millennium. Despite the sizable investments involved, these software packages were a breakthrough, especially in developed countries where they were installed by a vast majority of manufacturing firms (Olhager and Selldin, 2003; Jutras, 2010). After the initial excitement, however, an increasing number of managers have started to complain about the shortcomings of these systems. The main critique is that ERP systems impede making changes to business processes, which is a major problem in dynamic business environments where market requirements change rapidly (Rettig, 2007; Lindley et al., 2008; Goodhue et al., 2009; Ganly and Montgomery, 2012; Fauscette, 2013; IDG Market Pulse, 2013). Frustrated with the inflexibility of ERP systems, many managers have sought help from in-house developed software or traditional functionally specialized business applications (Upton and Staats, 2008; Deloitte, 2010; Prouty and Castellina, 2011; Ganly and Montgomery, 2012). Often, if the managers have not taken the initiative to replace the ERP system, their subordinates have begun to circumvent its use (Bendoly and Cotteleer, 2008; Xue et al., 2011; Christiansen et al., 2012).

Advocates of ERP systems abhor the implementation of standalone software as much as the circumvention tactics and claim that ERP systems can and should be always reconfigured when organizations change their business processes to serve new market requirements (Gattiker et al., 2005; Goodhue et al., 2009; Drobik and Rayner, 2011). They argue that the use of standalone tools or handcrafted spreadsheets compromises the main advantage of ERP systems, namely, the cross-functional integration that enables swift and reliable information flows across the organization (Berente and Yoo, 2012; Michael et al., 2012). The proponents of ERP systems do not perceive the alleged inflexibility as an obstacle but instead argue that the kind of rigidity that is inherent to ERP

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systems actually supports process reengineering and is therefore beneficial for organizations facing dynamic market requirements (Gattiker et al., 2005; Scott, 2011).

Management theory helps understand the controversy among practitioners over whether ERP systems facilitate or impede adaptation to changing market requirements. We use Teece's (2007) framework of dynamic capabilities to analyze the existing research and find out that ERP systems indeed have characteristics that both help and hinder organizational responses to dynamic market requirements. We then show that the conflicting arguments about the effects of ERP systems represent two different theoretical views on organizational adaptability. The argument that organizations facing dynamic market requirements must decentralize their management structures and rid themselves of the rules and standardized processes of ERP systems can be based on the Organic Theory of organization design (Burns and Stalker, 1961). The argument that these organizations benefit from the simplicity and discipline enforced by ERP systems can be based on Rigid Flexibility Theory (Collins and Schmenner, 1993). Although Organic Theory was first proposed over half a century ago, it has been widely used in the contemporary operations management research (e.g., Huang et al., 2010; Goodale et al., 2011; Zhang et al., 2012). Rigid Flexibility Theory is newer and less cited, but it too has received support in operations management research (Collins et al., 1998; da Silveira, 2006). Due to the theoretical backing for both perspectives, the dispute on whether ERP systems are beneficial or detrimental under dynamic market requirements cannot be settled via theoretical reasoning alone.

To address the question empirically, we analyze data from 151 manufacturing plants in 12 industry sectors, focusing specifically on the performance of *manufacturing planning and control activities* under varying levels of dynamism in market requirements. We use Platt's (1964) method of strong inference to test which of the two contradictory views is better supported in this empirical context. Finally, we discuss the theoretical generalizability of our findings by exploring the boundary conditions that may have influenced the results (Dubin, 1978).

2. Literature review

To position the present study within the existing literature, we next discuss ERP systems' status in today's enterprise software landscape and then explore the question of how ERP systems may help or hinder operational performance when organizations face dynamic market requirements.

2.1. ERP systems in the enterprise software landscape of the 2010s

ERP systems are modular software packages that integrate a firm's business functions around a common database and standardized processes that are configured to fit the needs of the user organizations (e.g., Boudreau and Robey, 2005; Ranganathan and Brown, 2006; Sasidharan et al., 2012). Substantial research efforts have been directed to this special category of enterprise software. The notorious failures of some of the early implementations (see examples in, e.g., Robey et al., 2002) gave rise to much research on the typical pitfalls and success factors of implementing ERP systems (for reviews and recent examples, see, e.g., Karimi et al., 2007; Seddon et al., 2010; Berente and Yoo, 2012; Sasidharan et al., 2012; Yeh and Xu, 2013). The variability in the outcomes of the implementations also motivated broad research on ERP systems' overall performance effects (e.g., Gattiker and Goodhue, 2005; Harris and Davenport, 2006; Ranganathan and Brown, 2006; Hendricks et al., 2007) and end users' assimilation of the implemented systems (e.g., Boudreau and Robey, 2005; Bendoly and Cotteleer, 2008; Saeed et al., 2010; Xue et al., 2011). A recurring finding in these studies has been that despite many successful examples (e.g., Cotteleer and Bendoly, 2006), the average overall performance effect of ERP systems has been fairly neutral (Bendoly et al., 2009), and that the variability in the effects cannot be fully explained with the implementation characteristics or the quality of use (Seddon et al., 2010). In response, the broad main streams of ERP system research have recently been complemented by studies that focus on specific contexts (e.g., Sarker et al., 2012; Lai et al., 2013) or pay special attention to ERP systems' fitness to external contingencies (e.g., Berente and Yoo, 2012; Sasidharan et al., 2012). This study extends both of these emerging trends.

Over time, the studies on ERP systems have also started to cover more specialized tools, such as customer relationship management, manufacturing planning, advanced production scheduling, supply chain management, and sourcing software (Hendricks et al., 2007; Sia and Soh, 2007; Stratman, 2007; Bendoly et al., 2008; Rai and Hornyak, 2013). This trend has been motivated by practical considerations, as firms have increasingly implemented standalone software (Deloitte, 2010; Fauscette, 2013). Although most firms do not have plans to completely abandon their ERP systems, many have implemented standalone tools to replace some functionality of their ERP systems (Ganly and Montgomery, 2012). Market research corroborates this trend by showing that the adoption rates of ERP system modules other than for financials and customer order handling have dropped considerably (Wailgum, 2008; Panorama Consulting, 2011) from the heyday of ERP systems in the early 2000s (Olhager and Selldin, 2003). Standalone tools are implemented especially in business functions where fitness to a firm's processes is critical, a good example being manufacturing planning and control (Brandl, 2011).

The trend in the increased use of standalone tools is interesting because it can be argued to compromise ERP systems' key value offering: swift and reliable intra-organizational information flows (e.g., Michael et al., 2012). Whenever some information is managed outside the database of the ERP system, the integrity and currency of the information are put in jeopardy, regardless of whether rudimentary spreadsheets or sophisticated business applications are used (Berente and Yoo, 2012). The trend is also interesting because research has shown that wider functional scope would be associated with greater benefits from ERP systems (Ranganathan and Brown, 2006; Karimi et al., 2007). These contradictions motivate studying the question of whether replacing ERP system functionality with other tools is good or bad for operational performance.

2.2. Dynamic capabilities perspective on ERP systems

Because ERP systems' inflexibility is the most often cited reason why managers consider replacing them with other solutions (Upton and Staats, 2008; Goodhue et al., 2009; Ganly and Montgomery, 2012), this study explores whether the dynamism of the operating environment influences the performance effects of ERP systems. In the management literature, dynamism traditionally refers to the *rate of change* in those aspects of an organization's environment that are not directly under its own control (Miller and Friesen, 1983). We focus on the rate of change *in market requirements* because it constitutes a great organizational challenge regardless of whether an ERP system or other software is used (Goodhue et al., 2009), as well as because research indicates that appropriate software is crucial to ensure "that firms can rapidly redesign existing processes and create new processes for exploiting dynamic marketplace conditions" (Sambamurthy et al., 2003, p. 245). This ability has been discussed as "market capitalizing agility" in the information systems literature (Lu and Ramamurthy, 2011) and under the rubric of "dynamic capabilities" in the management literature (Teece et al., 1997), yet it is not clear