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# IT-enabled Process Innovation: A Literature Review

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## ABSTRACT

The importance of Information Technology (IT) is growing, and in a hypercompetitive market IT must be used as a strategic asset for companies to succeed. In order to gain strategic benefits from IT, companies need to be innovative when deploying IT. This can be achieved by reengineering business processes to take advantage of the possibilities IT provides. In 1993 Thomas H. Davenport presented a framework describing "the role of IT in process innovation". Based on this framework, the purpose of this paper is to conduct a literature review to answer the following research question: "What kind of opportunities does IT provide for process innovation?". Davenport's framework is used as an analytical lens to review articles from the top 20 IS and management journals. The paper provides an overview and an in-depth analysis of the literature on IT-enabled process innovation and suggests avenues for future research as well as recommendations for practitioners. Our analyses reveal five distinct themes related to opportunities for IT-enabled process innovation, all of which offer guidance to practitioners and highlight gaps in our current knowledge about how to leverage IT for innovation purposes.

## Keywords

Process innovation, process reengineering, information technology, information systems, process automation, process improvement, strategic use of IT, and process change.

## INTRODUCTION

The importance of IT has increased from merely being a matter of technological support to becoming a strategic asset driving business transactions, organizational processes, and knowledge sharing (Applegate et al., 2009). Therefore, IT should be given the same attention as the enterprise strategy as a means to pursuing business opportunities (Pearlson and Saunders, 2007). According to Bill Gates, the role of IT has changed over the last three decades: "if the 1980s were about quality and the 1990s were about reengineering, then the 2000s will be about velocity" (Attaran, 2004: 586). This is supported by Pearlson and Saunders (2007) who argue that companies today are in a state of hypercompetition, meaning that markets change rapidly and competitive advantages can only be sustained temporarily before being neutralized. Therefore, companies have to innovate constantly in order to maintain a competitive advantage. The importance of innovation is emphasized by Tidd and Bessant (2009) according to whom "innovation is consistently found to be the most important characteristic associated with success" (Tidd and Bessant, 2009: 9). Innovative companies achieve stronger growth, higher market share and increased profitability in contrast to companies that do not innovate (Tidd and Bessant, 2009). Process reengineering is one of the means to staying innovative and to achieving performance improvement (Tidd and Bessant, 2009; Davenport, 1993). IT can be deployed as an enabler of radical process innovation (Davenport, 1993; Hammer, 1990) that in turn contributes to business success (Damanpour and Evan, 1984). IT-enabled process innovation is, therefore, a key answer to the challenge posed by hypercompetition, and companies are constantly on the lookout for new ways to innovate which leads us to our research question: "What opportunities does IT provide for process innovation?". In order to answer this question, Thomas H. Davenport's framework describing "the role of IT in process innovation" (Davenport, 1993) is used as our analytical lens in reviewing the literature on the subject. Davenport's framework focuses explicitly on IT as a source of process innovation making the framework suitable for our research purposes. An analysis of the literature based on all

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<sup>1</sup> Author names are arranged alphabetically to reflect an equal intellectual contribution.

categories in Davenport's framework provides an overview and solidifies our understanding of the field. In order to answer the research question, an in-depth analysis of IT provided opportunities for process innovation is conducted. However, to be able to provide recommendations in relation to opportunities, it is necessary to understand the environment in which the technology is used. Technology itself is not enough to ensure successful IT-enabled process innovation. To fully understand the opportunities, the organizational context and the implementation tasks must be understood.

The remaining paper is structured as follows. First, the theoretical background further investigates the process innovation field and describes Davenport's framework. Second, the review methodology is presented. This section explains how the literature review was conducted and elaborates on the use of Davenport's framework as an analytical lens. Third, the results of the literature review is presented and, fourth, the review results are discussed with the aim of identifying gaps in our state-of-the-art knowledge and providing guidance to practitioners.

## THEORETICAL BACKGROUND

Common definitions of the term innovation include "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003: 12) and "an idea or behaviour that is new to the organization adopting it" (Daft, 1978: 197). The literature on innovation can be divided into three streams: diffusion, innovation types, and innovation process phases (Swanson, 1994). These streams are found in both the general management literature and in the IS literature. Diffusion is the pattern of adoption over time by the innovation's target population (Rogers, 2003). The target population can be segmented into groups of adopters depending on their time of adoption, e.g. "early adopters" or "late majority". The term innovation is relatively broad. Robey (1986) and Zmud (1982) have, however, divided innovation into more specific domains. Innovations are divided into three categories, distinguishing between products or services, administrative innovations (improving internal control, coordination, and structure), and technical innovations (changes to technology or work processes) (Robey, 1986). Zmud (1982) separates product from process innovations. Product innovation is "the introduction of new products or services that shift or expand an organization's domain", and process innovation is "the introduction of new methods, procedures or responsibilities within existing domains" (Zmud, 1982: 1424). The category "process innovation" contains both administrative and technical innovations (Swanson, 1994). Administrative innovations tend to lag behind technical innovations. The reason for this lag is the fact that technical innovations are more observable and perceived as more advantageous. Furthermore, administrative innovations are considered more complex to implement (Damanpour and Evan, 1984). Both types of innovation, technical and administrative, reinforce one another to achieve high performance results (Daft, 1978). The last part of the innovation literature covers "innovation process phases" and is concerned with the life cycle of innovations from initiation, over adoption, to implementation (Swanson, 1994). One framework for "innovation process phases" is Davenport's framework, focusing on the use of IT in process innovation.

For the purpose of categorizing the process innovation literature, an analytical framework was needed. Eight candidate frameworks (Aguilar-Savén, 2004; Brooke, 2000; Childe et al., 1994; Davenport, 1993; Melão and Pidd, 2000; Motwani et al., 1998; van der Aalst and van Hee, 1995; Wastell et al., 1994) were identified. These eight frameworks were compared and evaluated in terms of usability as analytical tools. One of the frameworks is the "Process Analysis and Design Methodology" (PADM) which views process innovation in a business strategic context (Wastell et al., 1994). The PADM deals with the selection of a process for redesign which is subsequently defined, analyzed, evaluated, and redesigned. However, in terms of IT-enabled process innovation, this framework does not focus explicitly on how IT impacts process innovation. Another candidate was the "practical framework for BPR" which draws attention to the activities needed for BPR success (Motwani et al., 1998). These activities are labeled understanding, initiating, programming, transforming, implementing, and evaluating. Compared to PADM, this framework considers the role of IT as an implementation driver in process innovation. Although BPR is an approach that in general looks to IT as a source of innovation (Hammer, 1990), this framework is not concerned with how IT can be used as an enabler of innovation. Davenport's framework on "the role of IT in process innovation" is the only candidate framework which specifically considers IT both as a source of innovation (IT as enabler) and as a means to achieving innovation (IT as implementer). This explicit focus on IT both as a catalyst for and a means to implementing process innovations makes the framework an appropriate analytical lens for our literature review.

## ANALYTICAL FRAMEWORK

In his book "Process Innovation: Reengineering Work through Information Technology", Davenport presents a framework for IT-enabled process innovation (Davenport, 1993). Davenport is one of the most cited authors in the field of process innovation, and his framework provides an understanding of the relationship between IT and process innovation.



**Figure 1. The role of IT in process innovation (adapted from (Davenport, 1993: 49)).**

The framework (Figure 1) is composed of three dimensions: how IT impacts process innovation ("IT as Enabler"), how IT can be used to implement process innovations ("IT as Implementer"), and activities when designing new processes ("New Process Design"). "IT as Enabler" consists of the categories "Opportunities" and "Constraints" whereas "IT as Implementer" consists of the categories "Modeling Tools" and "Systems and Information Engineering". Each element must be considered when designing new processes ("New Process Design") (Davenport, 1993). On the one hand, IT conditions process innovation in terms of possibilities ("Opportunities" and "Constraints"). On the other hand, IT also facilitates the implementation of new processes (through "Modeling Tools" and "Systems and Information Engineering").

Although Davenport talks about Information Technology (IT), the framework covers Information Systems (IS) more broadly in the sense that it focuses on the interaction between technology, processes, and people. The framework shows how technology is used and influences the processes that people work by and try to innovate. In order to avoid confusion, we adopt the terminology used by Davenport and use the term IT rather than IS throughout the paper.

### Opportunities

When dealing with IT-enabled process innovation, the first thing to consider is the opportunities IT provides for process innovation (Davenport, 1993). Firstly, IT enables work automation in order to reduce or eliminate the human element from the process. Secondly, IT provides possibilities for processes to be executed simultaneously. Thirdly, IT makes it easier to monitor the status of work in progress, track goods being shipped from suppliers to customers, and coordinate activities across great distances. Fourthly, IT facilitates data collection and analysis as well as information dissemination and knowledge management. Davenport (1993) posits that an understanding of how IT can be used to innovate processes leads to better process design with regard to business objectives, e.g. time and cost reduction (Davenport, 1993). The opportunities provided by IT help the organization work more efficiently, intelligently, and aid monitoring and information processing.

### Constraints

Even though IT provides numerous opportunities for process innovation, it also introduces constraints which influence both current and future processes. When a process innovation is limited by current IT systems, either because they cannot be changed in the short run or because the change is too expensive, it is considered a constraint (Davenport, 1993). For instance, a new process design relying on opportunities for tracking shipments of goods from suppliers to customers can be constrained by the current IT system's inability to communicate with the suppliers' IT systems. IT systems provide only a limited number of features which constrain both current and future work processes.

### Modeling Tools

This category covers the tools facilitating "New Process Design". Examples include Business Process Management Systems (BPMS) that allow business analysts, system architects, and software engineers to change application supported processes in user friendly modeling environments. Enterprise Resource Planning (ERP) systems also serve as modeling tools by means of tailoring; ERP systems can be modified to accommodate process innovations. In turn, ERP systems are supported by database systems which provide information facilitating new process designs. Modeling tools are the technologies, software/systems, and programming languages that process innovations are implemented through. In essence, modeling tools are vehicles for implementing process innovations.

### Systems and Information Engineering

"Systems and Information Engineering" is the process of translating a conceptual process design into a design that is implementable by means of "Modeling Tools". It can, for example, be accomplished by the transformation of workflow diagrams ("New Process Design") into data flow diagrams and pseudo code ("Systems and Information Engineering"). These data flow diagrams and pseudo code can subsequently be implemented using "Modeling Tools". The distinction between

"Modeling Tools" and "Systems and Information Engineering" is, however, somewhat unclear since many tools serve both purposes. For instance, a BPMS can be used for both defining new processes and implementing the process design. In general, "Modeling Tools" and "Systems and Information Engineering" are to process innovation what instruments and notes are to music. Examples of "Systems and Information Engineering" include the creation of UML diagrams, prototypes, and ER diagrams.

### New Process Design

In addition to "Opportunities", "Modeling Tools", "Systems and Information Engineering", and "Constraints", Davenport argues that the process innovation design and its organizational implementation must be considered as well. According to Davenport, "New Process Design" is the process of considering different process designs, selecting a process design, and implementing it within an organization. Brainstorming and prototyping different process designs are also part of "New Process Design". In "Systems and Information Engineering" prototyping refers to techniques for creating prototypes of software products, whereas prototypes in "New Process Design" is the creation of prototypes of possible new process designs. In general, these activities can be considered as the process of designing new processes.

## REVIEW METHODOLOGY

In this section, our approach to conducting the literature review is presented. The literature review was a two-step process containing both quantitative and qualitative elements. The subsection "Selection of Literature" describes the quantitative selection of articles for the literature review whereas "Analysis of Literature" explains the qualitative analysis of these articles based on Davenport's framework.

### Selection of Literature

Having decided to focus on IT-enabled process innovation based on Davenport's framework, a review strategy was needed. It was decided to limit the search to the top 20 information systems and management journals (see Appendix A). The journals were selected using the AIS list of MIS journal rankings (<http://ais.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=432>) and (Mingers and Harzing, 2007). The decision to include both information systems and management journals is based on the fact that process innovation is a research area originally rooted in management science that has since spread to other scientific fields, e.g. information systems research. In order to identify relevant articles within the journals, various keywords were chosen to support the selection process. The term "process innovation" was selected for obvious reasons, but to ensure the comprehensiveness of the literature review, equivalent words and phrases were included as well. In addition to "process innovation", "process optimization", "process improvement", and "process automation" were chosen as search terms. The SciVerse Scopus database was used to search for articles in the selected journals using the chosen keywords. In Scopus, we looked for the search terms in either the title, abstract, or keywords. Our systematic search for these terms yielded 197 articles. The subsequent qualitative analysis of the literature resulted in the identification of the following additional search terms: "process redesign", "process reengineering", and "process change". A second search for articles using these terms was conducted resulting in 99 new articles. In total, 296 articles were identified.

### Analysis of Literature

In order to categorize the articles according to Davenport's framework (determining whether the main emphasis of an article is on "Opportunities", "Modeling Tools", "Systems and Information Engineering", "Constraints", or "New Process Design"), a qualitative judgment was made based on title and abstract. If a decision could not be reached based on abstract and title alone, the body text of the article in question was read. Each article was reviewed and categorized independently by the authors. The review results were compared and disagreements in terms of categorization were discussed. These discussions led not only to the categorization of all articles but also brought definitional clarity with regard to Davenport's framework. As a common understanding of the framework emerged among all three authors, the need to revisit the articles and double check our initial categorization arose. In order to ensure the reliability of our categorization, all articles were reassessed during two subsequent iterations of coding. These iterations resulted in a stepwise refinement of the categorization of articles and thereby strengthened the intercoder reliability of our effort (Miles and Huberman, 1994). During this iterative process, some articles were recoded as a shared understanding of the framework evolved among the authors. During the third iteration, the intercoder reliability was above 90%, and all remaining disagreements were resolved. To summarize, this process of "check coding" (Miles and Huberman, 1994) brought definitional clarity and confirmed the reliability of the coding across

researchers. In terms of definitional clarity, our discussions and disagreements forced us to state more clearly the definition of each code and helped us arrive at a shared understanding of all elements of Davenport's framework.

Due to our special attention to "Opportunities" for IT-enabled process innovation, articles belonging to this category were scrutinized to gain a thorough understanding of the content of this category.

Below is a list that summarizes the guiding principles behind our categorization of articles.

- Opportunities:
  - Technologies that can be used for process innovation.
  - How a specific technology is used in process innovation.
- Modeling Tools:
  - How tools are used to aid in the design of new processes.
- Systems and Information Engineering:
  - Methodologies that can be used for software/systems development in relation to process innovation.
- Constraints:
  - How existing IT systems constrain implementation of process designs.
- New Process Design:
  - Descriptions of process innovation philosophies.
  - How processes are documented.
  - Learning in relation to process innovation.

As noted earlier, process innovation is a topic that has attracted the interest of scholars both within the management and information systems fields. Consequently, the concept of process innovation covers a diverse and broad range of activities. This diversity is reflected in the literature where the content of some articles span two or more categories within Davenport's framework. The strategy for dealing with such articles was to identify each article's main contribution through a thorough assessment and categorize the article accordingly. Eventually, of the 296 articles that were initially identified through a quantitative selection, 126 articles were determined to be within the scope of Davenport's framework and categorized accordingly, whereas 170 articles were outside its scope. The part of the literature that was deselected deals with a variety of issues, including process innovations that are not IT-enabled and constraints/opportunities for process innovation that are unrelated to IT.

## REVIEW RESULTS

This results section includes an overall presentation of the literature as seen through Davenport's framework ("A Bird's Eye View of the Literature") and an in-depth presentation on the literature on "Opportunities" for IT-enabled process innovation ("A Worm's Eye View of Opportunities").

### A Bird's Eye View of the Literature

In the following subsections the literature within each category of Davenport's framework will be summarized. For each category, a number of research themes have been identified across articles and these will be described briefly. Table 1 provides an overview of the themes within each category of Davenport's framework and the corresponding references.

#### Opportunities

"Data exchange" is concerned with how IT can be used to innovate processes through the use of data. Numerous articles describe how data are used in IT-based process innovation. These articles focus on information gathering, automated data entry through scanning technology (Candler et al., 1996), the use of data to generate information (Bhandari et al., 1993) and the EDI (Electronic Data Interchange) standard for data transfer (Clark and Stoddard, 1996). "Decision support" deals with how IT can provide information that aids people in decision-making, for instance support tools for investment analysis (Meško and Meško, 1994). "Artificial intelligence" is about how IT can be employed to automate decisions, e.g. how AI based IT systems can analyze current process designs and from all available information suggest opportunities for process innovation (Datta, 1998; Min et al., 1996). Other articles within the "Artificial intelligence" theme center on how IT can be used to automate the process of planning (Rowe et al., 1996) and staffing (Bhandari et al., 2008). "IT-enabled communication" is concerned with how IT can be used to mediate communication between people. Examples include the use of IT for knowledge sharing (Malone et al., 1999) and how IT can provide access to needed documentation (Kock and

Davison, 2003). Yet another example is how IT can be used to facilitate the process of peer review (Mandviwalla et al., 2008). "Tracking" is about using IT to keep track of resources. An examples is the use of RFID chips to keep track of goods (Dos Santos and Smith, 2008; Hozak and Collier, 2008).

### Modeling Tools

"Process management systems" relates to the actual implementation of "New Process Design". Such systems are used for workflow management (Basu and Kumar, 2002) and implementation of process designs (Krishnamurthy and Rosenblum, 1995). "Process design tools" is an additional category of tools used for modeling processes. These tools facilitate the use of standardized notations to represent process designs (Sarker and Lee, 2006). An example is the use of tool support for the "cognitive maps" method on new process designs (Kwahk and Kim, 1999). Such business process visualization is an important success factor when using modeling tools (Im et al., 1999). "Simulation tools" is a category of tools used to test new process designs before they are implemented in "process management systems" (van der Aalst, 2001). Other modeling tools provide "Intellectual support" for the process designer. Examples of "Intellectual support" include Groupware tools which are used to facilitate the communication between process designers (Dennis et al., 2003).

### Systems and Information Engineering

"Tool development" concerns the development of software aimed at specialized tasks. An example is the development of tools for pricing and capacity sizing by describing the underlying algorithms (Maglaras and Zeevi, 2003). Articles in the "IT architecture" category are related to the conceptual design of IT systems facilitating process innovation. The architecture gives an overview of the interrelatedness between different components of software (Buzacott, 1996; Wang, 1997). "Design methodologies" refers to the process undertaken when designing new software. One part of this literature is concerned with the methodology used in the development process from conceptual models to working code (Curtis et al., 1992; Jun and Suh, 2002; Oshana, 1998). The other part of this literature deals with code reuse and guidelines to programmers on how to design code in order to make it reusable (Ravichandran, 1999; Visaggio, 1994).

### Constraints

Within the "Constraints" category only one theme was identified in the literature. Examples of "IT constraining process design" have been identified in relation to Business Process Reengineering (BPR) and Software Process Improvement (SPI). In BPR, for example, IT designs have constrained the implementation of new processes (Attaran, 2004; Broadbent et al., 1999; Bruckhaus et al., 1996).

### New Process Design

Articles within the "Learning" theme cover topics like learning from experiences (Card, 1998), employee training as a vehicle in promoting successful process implementation (Davenport and Beers, 1995; Tucker et al., 2007), and knowledge sharing as a means to improving existing processes (Patnayakuni et al., 2007). The "SPI characteristics" theme relates to the philosophy underlying improvement initiatives, e.g. SPI as a journey rather than a destination (Hardgrave and Armstrong, 2005) and success factors in SPI efforts (Fitzgerald and O'kane, 1999). "SPI practices" concerns guidelines on how to design software processes. Example articles within this theme deal with agile practices (Batra, 2009; de Cesare et al., 2010), defect reduction (Rooijmans et al., 1996), and best practices in SPI (Dutta et al., 1999). "Standards compliance" is about improving software processes by complying with industry standards and best practices like the Capability Maturity Model (CMM) (Humphrey et al., 1991; Wiegers and Sturzenberger, 2000). Some articles focus on barriers and success factors in implementing process improvements and tailoring best practice models like the CMM to various organizations (Johnson and Brodman, 2000), incl-

Category	Theme	Reference	#
Opportunities	Data exchange	(Candler et al., 1996), (Clark and Stoddard, 1996), (Lee et al., 1999), (Chatfield and Bjørn-Andersen, 1997), (van den Heuvel and Maamar, 2003), (Ward and Zhou, 2006)	6
	Decision support	(Meško and Meško, 1994), (Wang and Tadisina, 2007), (Nissen and Sengupta, 2006), (Böhme and Wieland, 1990), (Balakrishnan and Semmelbauer, 1999), (Bhandari et al., 1993)	6
	Artificial intelligence	(Hamscher, 1994), (Nissen, 2001), (Datta, 1998), (Rowe et al., 1996; Bhandari et al., 2008), (Widrow et al., 1994), (Min et al., 1996)	7

	IT-enabled communication	(Mandviwalla et al., 2008), (Malone et al., 1999), (Kock and Davison, 2003), (Lee and Clark, 1996)	4
	Tracking	(Dos Santos and Smith, 2008), (Hozak and Collier, 2008), (Bose and Pal, 2005)	3
Modeling Tools	Process management systems	(Basu and Kumar, 2002), (Krishnamurthy and Rosenblum, 1995)	2
	Process design tools	(Sarker and Lee, 2006), (Kwahk and Kim, 1999), (Im et al., 1999)	3
	Simulation tools	(van der Aalst, 2001), (Changchien and Shen, 2002)	2
	Intellectual support	(Sarker and Lee, 2006), (Dennis et al., 2003), (Kim et al., 1997)	3
Systems and Information Engineering	Tool development	(Kumar and Zhao, 1999), (Maglaras and Zeevi, 2003), (Chidamber and Kemerer, 1994)	3
	IT architecture	(Buzacott, 1996), (Wang, 1997)	2
	Design methodologies	(Jun and Suh, 2002), (Curtis et al., 1992), (Oshana, 1998), (Ravichandran, 1999), (Visaggio, 1994)	5
Constraints		(Bruckhaus et al., 1996), (Broadbent et al., 1999), (Attaran, 2004)	
	IT constraining process design		3
New Process Design	Learning	(Ittner et al., 2001), (Hatch and Mowery, 1998), (Nolan, 1999), (Card, 1998), (Marcellus and Dada, 1991), (Brock et al., 2009), (Kandt, 2009), (Davenport and Beers, 1995), (Tucker et al., 2007), (Ramasubbu et al., 2008), (Johnson and Disney, 1998), (Wohlwend and Rosenbaum, 1994), (Patnayakuni et al., 2007), (Duranton and Puga, 2001), (Terwiesch and Xu, 2004), (Kim and Kim, 1998), (Cho and Eppinger, 2005)	17
	SPI characteristics	(Fitzgerald and O'kane, 1999), (Hardgrave and Armstrong, 2005)	2
	SPI practices	(Mangalaraj et al., 2009), (de Cesare et al., 2010), (Batra, 2009), (Jørgensen, 2005), (Rooijmans et al., 1996), (Napier et al., 2009), (Dutta et al., 1999), (Conradi and Fuggetta, 2002),	8
	Standards compliance	(Ngwenyama and Nielsen, 2003), (Johnson and Brodman, 2000), (Wieggers and Sturzenberger, 2000), (Humphrey et al., 1991), (Murugappan and Keeni, 2003), (Dangle et al., 2005), (Curtis, 2000), (Caffery et al., 2007), (Sommerville and Ransom, 2005), (Diaz and Sligo, 1997), (Herbsleb et al., 1997), (Work, 2002), (Clark, 2000), (Börjesson and Mathiassen, 2004), (Hollenbach et al., 1997)	15
	Measurement as innovation driver	(Lee and Ahn, 2008), (Thomas and Smith, 2001), (Jalote and Saxena, 2002), (Hoopes and Triantis, 2001), (Kitchenham et al., 1995), (Daskalantonakis, 1992), (Kilpi, 2001), (Pfleeger and Rombach, 1994), (Nissen, 1998), (Gregoriadesa and Sutcliffe, 2008)	10
	Philosophies	(Jakobsen, 1998), (Thomas and McGarry, 1994), (Hackbarth and Kettinger, 2004), (Barua et al., 1996), (Ittner and Larcker, 1997), (Ngwenyama and Nørbjerg, 2010)	6
	Process redesign frameworks	(Earl et al., 1995), (Aaen, 2003), (Luo and Strong, 2004), (Carrillo and Gaimon, 2002), (Changchien and Shen, 2002), (Schmidt, 1996)	6
	Modeling techniques	(van der Aalst, 2001), (Yan et al., 2002), (Lee et al., 2008), (Sun et al., 2006), (Katzenstein and Lerch, 2000), (Turetken and Schuff, 2007), (Sommerville et al., 1999), (Gorschek et al., 2010), (Kim and Kim, 1997), (Zantek et al., 2002), (Wang and Zhao, 2011), (Reijers et al., 2003), (Kettinger et al., 1997), (Kock et al., 2009), (Bradley and Guerrero, 2011)	15
<b>Total</b>			<b>126</b>



**Table 1. Review results**

uding different organizational culture types (Ngwenyama and Nielsen, 2003). "Measurement as innovation driver" contains articles that are concerned with how measurements of, for example, cycle times can affect and help drive process innovation. By designing new processes based on evaluation of cycle times (Daskalantonakis, 1992) better organizational performance can be achieved (Lee and Ahn, 2008). Means of assessing current organizational performance include benchmarking (Thomas and Smith, 2001) and comparative case studies (Kitchenham et al., 1995). Other articles deal with setting the right performance metrics to enable organizational performance evaluation (Jalote and Saxena, 2002) and implementing those metrics (Kilpi, 2001). "Philosophies" refers to different perspectives on how to innovate processes. There are, for example, in the literature distinctions between, on the one hand, incremental and radical innovations (Hackbarth and Kettinger, 2004) and, on the other hand, top-down versus bottom-up approaches to innovation management (Jakobsen, 1998; Thomas and McGarry, 1994). The theme "Process redesign frameworks" has to do with overall views of the activities related to doing process innovation. Such frameworks relate to process innovation in different contexts, like adapting processes in ERP systems implementation (Luo and Strong, 2004) and combining engineering and production activities for the purpose of innovating manufacturing processes. "Modeling techniques" refers to notational languages that allow for the documentation of process designs. Some articles within this theme discuss how to describe the social context (Katzenstein and Lerch, 2000) through the use of notations (Turetken and Schuff, 2007). Other articles reflect on the actual design, like how to merge or sequence process activities (Sun et al., 2006; van der Aalst, 2001; Yan et al., 2002).

### **A Worm's Eye View of Opportunities**

The theme "Tracking" is concerned with describing applications of RFID chips. Such chips communicate with receivers by means of radio waves to enable tracking of objects on the move (Hozak and Collier, 2008). In its simplest form RFID chips carry information regarding the location and identification of an object, but more advanced chips also contain time stamps, temperatures (Dos Santos and Smith, 2008), and expiration dates (Bose and Pal, 2005). RFID technology is replacing barcodes which have been used as a way of tracking goods before the invention of RFID (Hozak and Collier, 2008). However, RFID is more efficient than barcodes due to the fact that tracking objects marked with barcodes requires human labor to scan each barcode manually while RFID labeled objects can be identified automatically and concurrently in seconds by means of receivers. As a consequence, lot splitting is, for example, more profitable when used in conjunction with RFID, because fewer resources are required to perform the more comprehensive task of tracking lots (Hozak and Collier, 2008).

"IT-enabled communication" refers to the use of IT to make it possible for people to cooperate and solve tasks across physically separated locations. Two pools of articles deal with how to mediate the process redesign activities in a geographically dispersed environment. One approach is to develop a process handbook aimed at helping people redesign existing processes, invent new processes, employ IT, and share ideas (Malone et al., 1999). Another approach to supporting the mental challenge of redesigning business processes is the usage of lean communication media such as e-mail (Kock and Davison, 2003). Evidently, there are differences between using process handbooks and lean communication media in process redesign; the first approach focuses on sharing explicit knowledge whereas the second approach is aimed at facilitating interaction among individuals to allow for knowledge sharing. The peer review process is an example of an activity that can be improved by means of IT in order to facilitate concurrent and engaged conversations (Mandviwalla et al., 2008). In all organizational aspects, it is possible to take advantage of IT to create process innovations that are radically different from the existing process design (Mandviwalla et al., 2008). IT can, for example, be used to facilitate B2B trading through electronic market systems (Lee and Clark, 1996), allowing buyers and sellers to interact, negotiate, and exchange information through technology.

"Artificial intelligence" can aid in the design of new processes by providing the means to identifying current business processes (Datta, 1998) and to propose and evaluate alternative process design improvements (Hamscher, 1994; Min et al., 1996; Nissen, 2001). One example of AI being employed to design new processes is the use of IT to forecast staffing needs at call centers (Bhandari et al., 2008). IT makes this possible by providing computing power to predict staffing needs based on available statistics. Similarly, AI can be used to plan and manage supply chain activities and thereby radically improve efficiency, for example by changing delivery schedules from weekly to daily (Rowe et al., 1996). A trend within "Artificial intelligence" is the use of neural networks, referring to the employment of electronic neurons to create an artificial brain capable of identifying patterns, making predictions, enforcing financial control, and proposing optimizations (Widrow et al., 1994).

As mentioned, "Decision support" refers to the application of IT to support decision-making. This theme is related to AI in the sense that computers are used for problem-solving. However, "Decision support" applies logic to support decision-making (Böhme and Wieland, 1990; Meško and Meško, 1994; Wang and Tadisina, 2007). This can, for example, be achieved

by creating adaptive tools that are capable of handling “combinatorial problems” (Böhme and Wieland, 1990). A more radical approach is to allow an IT system to act as a decision-maker whenever possible and only involve people in the process when needed, e.g. in the case of ambiguity (Nissen and Sengupta, 2006). Instead of creating decision support according to predefined rules, a case based approach can be applied that allows rules to be deduced from ongoing experiences (Balakrishnan and Semmelbauer, 1999). This is achieved by providing IT systems with information based on experiences from past troubleshooting sessions and thereby aiding the decision-making process during future troubleshooting instances. Similarly, IT aided data exploration can support project teams in identifying possible process innovations over the course of a project (Bhandari et al., 1993).

“Data exchange” focuses on how IT can be employed to distribute information within companies and across the supply chain. Such distribution of information by means of IT potentially reduces lead time as evidenced by various lean implementations (Ward and Zhou, 2006). On a related note, Electronic Data Interchange (EDI) is the concept of transferring data across the value chain (Clark and Stoddard, 1996). Among other places, it has been used within the U.S. groceries market, yielding benefits to both suppliers and buyers in the value chain (Lee et al., 1999). [56]Japan Airlines applied EDI to manage value chain logistics and improve coordination which has resulted in a more lean and responsive enterprise (Chatfield and Bjørn-Andersen, 1997). FedEx is another company that is using EDI successfully. The company has created text recognition software that allows for easier data exchange through scanning and distribution of documents across borders (Candler et al., 1996). [57]Van den Heuvel & Maamar (2003) take a different perspective on EDI. They describe the concept of “virtual enterprises” which create an IT infrastructure across enterprises by connecting individual IT systems through web services (van den Heuvel and Maamar, 2003).

## DISCUSSION

Out of the 126 reviewed articles, only three fall within the “Constraints” category. These articles emphasize, however, the important role played by IT in determining whether process innovations succeed or fail (Attaran, 2004; Broadbent et al., 1999; Bruckhaus et al., 1996) which makes it all the more surprising that so few articles deal with this subject. One possible explanation for this lack of research is difficulties in finding companies that are willing to publicly admit to innovation failures. “Constraints”, however, is also the most narrowly defined category in Davenport’s framework resulting in only a few articles fitting the relevance criterion for this category. Another reason for the lack of literature is that other barriers to successful IT-enabled process innovation are located within the “New Process Design” category. Topics like organizational culture, change management, and resistance to change are well-known barriers to successful IT implementation (Cooper, 1994). Articles concerned with these issues are absent in the reviewed literature which might be due to the fact that such articles are more general in scope and do not focus narrowly on IT-enabled process innovation. Articles investigating implementation barriers in broader contexts also contribute to our understanding of the challenges associated with IT-enabled process innovation due to the general nature of the subject. Meanwhile, the small amount of literature on “Constraints” does not reflect the importance of the subject. The growing importance of technology makes research on the constraining impact of IT on companies’ abilities to achieve and sustain competitive advantages relevant. In a hypercompetitive market companies need flexibility in order to cope with rapid changes in the environment. As a consequence, future research should focus on how IT systems can help companies achieve flexibility and not be constrained by technology. Table 2 summarizes the implications of our study and our advice to researchers and practitioners.

	<i>Practical guidance</i>	<i>Future research</i>
<b>General observations</b>	<ul style="list-style-type: none"> <li>- Align IT-enabled process innovations with the organization</li> <li>- Support implementation by supplementing process development with other activities, e.g. training</li> <li>- Use cross-functional teams with broad range of needed organizational and IT skills</li> <li>- Be mindful of process interdependence and look out for unanticipated consequences</li> </ul>	<ul style="list-style-type: none"> <li>- Investigate how IT systems can help companies achieve flexibility and not be constrained by technology</li> <li>- Explore the intended and unintended consequences of IT-enabled process innovation</li> </ul>
<b>Tracking</b>	<ul style="list-style-type: none"> <li>- Consider what data to store and register on RFID chips in the absence of useful security measures</li> <li>- Prepare a business case that investigates the financial and non-financial gains of an investment in the technology</li> </ul>	<ul style="list-style-type: none"> <li>- Investigate how to enhance RFID security without compromising the advantages of the technology, e.g. flexibility</li> <li>- Study ROI in RFID technology</li> </ul>
<b>IT-enabled</b>	<ul style="list-style-type: none"> <li>- Consider how existing and emergent technologies can be</li> </ul>	<ul style="list-style-type: none"> <li>- Identify different solutions that can be used</li> </ul>

<b>communication</b>	deployed to provide employees with new opportunities for interaction	to drive process innovation under varying circumstances
<b>Artificial intelligence</b>	- Consider the maturity of AI systems before investing in experimental technology	- Investigate the AI potential of the 2010s
<b>Decision support</b>	- Distinguish between critical and non-critical decisions when contemplating solutions for IT-based decision support, and delegate trivial decisions to IT systems	- Explore the possibilities and limitations of IT in the decision-making process
<b>Data exchange</b>	- Rely on the internet as the underlying data exchange platform, e.g. through cloud computing - Consider flexibility of current data exchange formats and interfaces in communicating with value chain participants	- Identify standards for data exchange and integration across the value chain

**Table 2. Research implications**

Looking at the distribution of articles across categories, some interesting observations can be made. There are considerably more articles within the "New Process Design" category than articles about "Opportunities", (80 and 25 articles, respectively). It is noteworthy that so many articles concern the process of innovating processes ("New Process Design") rather than the opportunities for process innovation provided by IT ("Opportunities"). This implies that even though IT provides significant opportunities for process innovation, it is only a subset of factors that influence successful process innovation. In order for IT-enabled process innovation initiatives to be successful, process development needs to be complemented by other activities that support implementation efforts. One example of such activities is "Learning", referring to the training of employees which enables them to take advantage of the process innovations (Davenport and Beers, 1995; Tucker et al., 2007) and, in turn, ensure benefit realization. These articles demonstrate that no matter how good the design and performance of new processes, the innovations cannot stand alone but need to be supported by other activities to ensure implementation success. Another theme within the "New Process Design" category is "Philosophies" which contains different perspectives on how to carry out process innovation. One question to consider when planning for innovation management is whether to rely on a top-down or bottom-up approach to implementation (Thomas and McGarry, 1994). There is no one-size-fits-all solution. Rather, the answer depends on the innovation context. A case in point is the employment of RFID technology. Having identified RFID as a desirable technology ("Opportunities"), processes supporting the use of RFID need to be designed ("New Process Design"). Such processes should not only take advantage of the technology but also consider organizational issues. Afterwards, implementation of the innovation is planned ("Systems and Information Engineering") and might be executed using various "Modeling Tools". During these activities, potential constraints imposed by the current IT architecture should be identified. Even though IT is a catalyst for process innovation, it does not guarantee successful implementation. Other factors impact implementation, and it is important that the IT-enabled process innovations are aligned with the organization. In order to achieve alignment, employees and teams tasked with innovating business processes should be cross-functional to ensure a broad range of needed organizational and IT skills.

The in-depth look at "Opportunities" revealed tendencies within each theme. All articles within the "Tracking" theme are concerned with the emergence of RFID as a substitute for barcode technology (Bose and Pal, 2005; Hozak and Collier, 2008). RFID enables radical redesign of business processes related to goods and parcel tracking removing the human element and resulting in higher process velocity. This opportunity for process innovation may help companies facing hypercompetition gain a temporary competitive advantage. RFID is, however, a relatively open technology which means that anybody can read the content of a chip. This openness gives, on the one hand, great flexibility in terms of application but, on the other hand, this openness creates new security risks in the sense that competitors can get hold of sensitive information by analyzing data on RFID chips. Preventive measures can be taken, but current security measures reduce the flexibility and financial benefits of RFID technology (Dos Santos and Smith, 2008). Future research should, therefore, focus on enhancing RFID security without compromising the advantages of the technology. Furthermore, practitioners are advised to carefully consider what data to store and register on RFID chips in the absence of useful security measures. In addition, the financial benefits of RFID technology have only received scant attention. As a consequence, another avenue for future research is to investigate the return on investments in RFID technology, for example when an investment in RFID scanners and the supporting infrastructure will break even. If the break-even point is too far into the future, RFID might already have been superseded by competing technologies in a fast paced hypercompetitive market. Practitioners should also prepare a business case that investigates the financial and non-financial gains of an investment in the technology.

"IT-enabled communication" reflects the development in communication technology from the 1990s to the 2000s. The trend of the 1990s was distribution of information by means of, for example, knowledge management systems (Malone et al.,

1999) and various systems that facilitate information sharing in a B2B context (Lee and Clark, 1996). In the 2000s the trend shifted toward the facilitation of interaction between individuals, e.g. collaboration during reviews (Mandviwalla et al., 2008) and e-mailing as an enabler of lean communication (Kock and Davison, 2003). In short, the trend is shifting from distribution of information to facilitation of interaction. This development is the result of hypercompetition which, among other things, drives companies to offshore some of their activities, resulting in the need for cross-border collaboration. Moving toward greater interaction, there are different perspectives on how IT can facilitate collaboration, e.g. through conversational technologies and CSCW (Computer Supported Cooperative Work) tools. Further research is, however, needed, to identify different solutions that can be used to drive process innovation under varying circumstances. Practitioners should carefully consider how existing and emergent technologies can be deployed to provide employees with new opportunities for interaction which, in turn, help them compete in an increasingly competitive market.

Early articles on "Artificial intelligence" explore the opportunities AI provides for process innovation, describing a future that is as yet unattainable, e.g. reliable speech recognition (Widrow et al., 1994) and automated business process discovery (Datta, 1998). Current "Artificial intelligence" literature takes a more pragmatic stance, providing concrete examples of how AI can be used to rethink existing processes, for example by using it for optimal staffing of call centers (Bhandari et al., 2008). In the 2000s the focus was on practical applications of AI and the field was still far from reaching the potential described in the 1990s. The number of articles exploring AI based opportunities for process innovation had decreased by 60 % from the 1990s to the 2000s. Although this downward trend is based on relatively few articles, it is noteworthy that it coincides with a change in focus from utopian ideas to actual implementation. This downward trend may simply reflect that the technology has not yet matured to the point where these ideas are realizable. However, future research should investigate the AI potential of the 2010s. Current developments, like the Wolfram|Alpha computational knowledge engine (<http://www.wolframalpha.com>) and Siri – Apple's intelligent personal assistant with built-in speech recognition (<http://www.apple.com/iphone/features/siri.html>) – indicate that some of the aforementioned utopian ideas are in fact being translated into practice. Yet, practitioners are cautioned to carefully consider the maturity of AI systems before investing in experimental technology that may not deliver the promised value.

Compared to "Artificial intelligence", "Decision support" shows the opposite trend. Early articles describe computer support for human decision-making (Böhme and Wieland, 1990). This stands in contrast to the AI ideal where IT replaces humans as the primary decision-makers. However, the latest trend with regard to "Decision support" is to delegate trivial decisions to IT systems and solve them through computational logic (Nissen and Sengupta, 2006). By allowing computers to assume decision-making responsibilities, the distinction between "Artificial intelligence" and "Decision support" becomes blurred. However, in case of ambiguity and complexity human authority is still needed. Future research should extend our current knowledge about the possibilities and limitations of IT in the decision-making process. Practitioners are advised to distinguish between trivial/non-trivial and critical/non-critical decisions when contemplating solutions for IT-based decision support.

All articles within the "Data exchange" theme deal with the importance of data flow between IT systems in the value chain. New literature argues that data exchange will rely on the internet as the underlying platform in the future (van den Heuvel and Maamar, 2003). Recently, an important innovation has been the advent of cloud computing, moving activities and applications into the "cloud" (Zissis and Lekkas, 2012). Cloud computing breaks down the distinction between activities that are inside and outside the organization, and it underscores the need for data exchange and tailoring to ensure seamless process integration. Researchers may have lost interest in "Data exchange", being an old and mature application of IT, but the principles need to be updated to fit a global world of hypercompetition in order to deliver seamless integration across the value chain. Our review did not reveal any standards for data exchange and integration across the value chain. Since seamless integration is impossible without such standards, future research should focus on this area of concern. Practitioners should consider the possibilities and limitations of data exchange. For example, are current data exchange formats and interfaces flexible enough to communicate with a broad variety of value chain participants.

Despite their differences, all articles share an interest in radical changes to existing business processes enabled by IT, for example fast and flexible shipment based on RFID technology (Hozak and Collier, 2008), an improved peer review process (Mandviwalla et al., 2008), and automation of call center staffing decisions (Bhandari et al., 2008). Such radical innovations not only impact the processes themselves but also the surrounding environment. A new RFID enabled process, for instance, not only changes logistics at the warehouse but also how other parts of the business handle and track the flow of goods. Former processes in all parts of the organization become obsolete and must be replaced or reengineered. Practitioners should be aware of this process interdependence and look out for unanticipated consequences, for example how different departments are affected and require new work procedures. Additional research about the intended and unintended consequences of IT-enabled process innovation is needed.

## LIMITATIONS

This literature review is shaped and limited by our choice of analytical framework (Davenport) and journals. By focusing on the top 20 IS and management journals we have provided an overview of trends and themes within highly esteemed research outlets. However, this decision has excluded conference papers and articles in other journals, some of which are more likely to publish novel and radical ideas due to lightweight review processes. The negative consequence is that less mainstream research may have been excluded from the review. On a more positive note, our selection criterion is more likely to exclude research on isolated phenomena without practical applications. Exclusion of such papers and articles eases the task of identifying trends and themes across the literature.

Similarly, the choice of Davenport's framework as our analytical lens has influenced the review results. The framework does not focus on all aspects of process innovation. It centers on the role of IT to the exclusion of other relevant aspects like people issues and organizational factors. However, due to our interest in the transformational potential of IT, it is an appropriate analytical lens for this literature review. Having categorized 126 articles, we have learned a number of lessons about the framework. These are formulated as answers to questions about the applicability of Davenport's framework. First, is Davenport's framework from 1993 outdated in 2012? No. The categories are sufficiently generic to be useful as analytical frames when trying to establish an overview of a large and diverse set of articles. It was, for example, unproblematic to categorize an emerging technology like RFID as an opportunity for process innovation. Second, is Davenport's framework too broad to allow for interesting and relevant analyses? No. The use of general search terms like "process innovation" results in a pool of heterogeneous articles which necessitates a broad analytical framework to prevent relevant literature from being excluded. When the goal is to get an inclusive perspective on IT-enabled process innovation, the framework is a suitable analytical lens. Third, are there any challenges in applying the framework for analytical purposes? Yes. The categories of the framework are interrelated, and the contributions of many articles are ambiguous and multi-faceted, making it difficult to categorize the articles unequivocally. As previously mentioned, the solution was to focus on the main contribution of each article. Fourth, are other frameworks equally applicable? No. In the Theoretical background section, three alternative frameworks (including that of Davenport) were emphasized. Although they focus on process innovation, none of the frameworks include IT-based opportunities and constraints in process innovation. Excluding these categories from the review would prevent us from answering the research question. As a consequence, none of the alternative frameworks would be an appropriate substitute for Davenport's framework. Fifth and finally, does Davenport's framework have any limitations? Yes. During the review, articles that deal with organizational issues in process innovation, e.g. organizational culture (Shih and Huang, 2010), were identified. Since these articles fall outside the scope of the review, they were excluded even though these factors clearly contribute to process innovation success or failure.

## CONCLUSION

In a state of hypercompetition, IT-enabled process innovation is key to gaining a competitive edge, and companies are increasingly forced to explore new opportunities to reap the strategic benefits of IT. This goal can be achieved by reengineering business processes and taking advantage of IT in the process. The purpose of this paper is to investigate the opportunities for IT-enabled process innovation. First, we provide a bird's eye view of the process innovation field and, in turn, an in-depth analysis of the opportunities IT provides for process innovation. The in-depth analysis reveals five themes: "Tracking", "IT-enabled communication", "Artificial intelligence", "Decision support", and "Data exchange". Our analysis shows that process innovation is a set of interrelated yet distinctive activities, and opportunities for IT-enabled process innovation should not be examined in isolation but should be considered in relation to other organizational factors influencing innovation success or failure. Having provided an overview of the literature and an in-depth look at the opportunities for IT-enabled process innovation, the paper discusses the implications for research and practice. Thus, the paper helps both researchers and practitioners in locating literature relevant to their studies or reengineering efforts.

## APPENDIX A

#	<i>IS Journals</i>	<i>Management Journals</i>
1	MIS Quarterly	Psychological Bulletin
2	Information Systems Research	Quarterly Journal of Economics
3	Communications of the ACM	Journal of Finance
4	Management Science	Administrative Science Quarterly
5	Journal of Management Information Systems	Marketing Science
6	Artificial Intelligence	Journal of Financial Economics
7	Decision Sciences	Journal of Political Economy
8	Harvard Business Review	Information Systems Research
9	IEEE Transactions (various)	Econometrica
10	AI Magazine	Journal of Marketing Research
11	European Journal of Information Systems	American Economic Review
12	Decision Support Systems	Journal of Marketing
13	IEEE Software	Academy of Management Journal
14	Information & Management	Journal of Economic Literature
15	ACM Transactions on Database Systems	American Journal of Sociology
16	IEEE Transactions on Software Engineering	Management Science
17	ACM Transactions (various)	Academy of Management Review
18	Journal of Computer and System Sciences	Journal of the American Statistical Association
19	Sloan Management Review	Journal of Accounting Research
20	Communications of the AIS	Journal of Monetary Economics

Table A. List of top 20 IS and Management journals<sup>2</sup>

<sup>2</sup> Source: AIS list of MIS journal rankings (<http://ais.affiniscap.com/displaycommon.cfm?an=1&subarticlenbr=432>) and (Mingers and Harzing, 2007).

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