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A perspective on applications of in-memory analytics in supply chain management

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ABSTRACT

Big data, advanced analytics, and in-memory database technology are on the agenda of top management since they are seen as key enablers for enhanced business decision-making. In this paper, we provide a comprehensive perspective on applications of in-memory analytics in the field of supply chain management (SCM) that use the aforementioned concepts. Our contribution is threefold: First, we develop a top-down framework to position in-memory analytics applications against extant IT systems in SCM. Second, we conduct a bottom-up categorization of 41 in-memory analytics applications in SCM to provide supporting empirical evidence of the efficacy of the framework. Third, by contrasting top-down and bottom-up perspectives we derive implications for research and industrial practice.

1. Introduction

Business analytics and related concepts that describe the analysis of business data for decision-making purposes have received widespread attention in both the academic and business communities [1–4]. Top managers generally see business analytics as a differentiating factor for competitive advantage and thus are increasingly interested in capturing this value potential [5,6]. McAfee and Brynjolfsson [7] report an increase of 5 to 6% in productivity for companies that place in the top third of their industries in the use of business analytics. The positive impact of business analytics capabilities on supply chain performance is also confirmed in several empirical studies [8–10]. Moreover, Brown et al. [11] and Waller and Fawcett [12] indicate the disruptive potential of data-driven decision-making for business and operations management in particular.

In the slipstream of this development, major software providers hype in-memory database technologies [13,14] that enable real-time business intelligence [15] and support big data analytics, i.e., business analytics using large volumes of complex data [1]. In-memory database systems allow for high-speed processing and analysis of large data volumes [16] by storing data directly in main memory, avoiding time-consuming hard disk operations [17]. The emergence of in-memory database systems has been further promoted by enhanced data management procedures and multi-core hardware architectures that have recently become available [18]. This raises the question whether novel business applications that build on in-memory database systems will only 'do things differently' or will actually allow users to 'do different things'. vom Brocke et al. [19] investigate similar aspects in their case study from the Hilti Corporation when assessing second-order benefits that can be captured by applying in-memory technology.

Piller and Hagedorn [20] describe exemplary use cases and potential benefits of business applications enabled by in-memory database technology. Real-time business intelligence represents one specific use case that has already been investigated for domain-specific applications in customer relationship management (CRM) [21] and supply chain management (SCM) [22]. Further applications in SCM deal with real-time order promising [23] and sales and operations planning (S&OP) [24]. In-memory-enabled applications for supply chain planning are generally seen as on the rise [25], which is confirmed by a multitude of SCM-related solutions that have been recently launched [26,27]. The relevant literature, however, lacks a comprehensive overview of relevant use cases of emerging in-memory analytics applications in SCM. More importantly, there is a need for studies that yield implications for research and industrial practice in this field.

In-memory technology and business analytics are nothing new to SCM, having accompanied the emergence of Advanced Planning and Scheduling (APS) systems at the end of the 1990s [28]. APS systems have been deployed on top of Enterprise Resource Planning (ERP) systems to overcome their shortcomings in production planning and scheduling [29]. For this purpose, they apply forecasting methods and mathematical optimization models that require in-memory cache technology to perform the calculations [30]. However, APS systems have been criticized for several functional and technical shortcomings [29, 31]. Emerging in-memory technology concepts could provide potential avenues for resolving these problems or even constitute an alternative

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[24]. Unfortunately, we have yet to see a thorough delineation of APS systems in relation to emerging in-memory analytics applications.

The objective of this paper is to develop a comprehensive perspective on analytics applications in SCM that build on in-memory technology. This perspective could answer the abovementioned question whether emerging in-memory analytics applications will only enhance current practice or will eventually support novel approaches in supply chain decision-making. Our approach is threefold: First, a conceptual top-down framework is derived using grounded literature on business analytics approaches and DSS methodology that allows for a thorough positioning of in-memory analytics applications against extant IT systems in SCM. Following a bottom-up empirical approach, we then examine and systematically structure 41 in-memory analytics applications for SCM to outline the current focus. Lastly, by contrasting top-down and bottom-up perspectives we identify areas with the potential for advancing the use of in-memory analytics in SCM and derive implications for both research and practice.

2. A framework for analytics applications in SCM

2.1. Overview and business analytics approach

In this section, we develop a comprehensive framework for analytics capabilities in SCM (see Fig. 1) using a conceptual deductive approach. For this purpose, we build on two recent publications of Holsapple et al. [3] and Mortenson et al. [4] that discuss the foundations of business analytics. Holsapple et al. [3] describe three taxonomies of analytics orientation that differentiate with respect to the analytics task, result, or benefit. We adopt the task-oriented taxonomy of analytics to structure the pivotal dimension of our framework since it appears to be the most frequently used option and best serves our purpose of characterizing analytics applications.

The task-oriented taxonomy distinguishes three distinct analytics approaches [3,32]: descriptive, predictive, and prescriptive. *Descriptive analytics* summarize and convert data into meaningful information for reporting and monitoring purposes, but also allow for detailed investigation to answer such questions as “what has happened?” and “what is happening at the moment?” [4]. Data modeling is a prerequisite when making authoritative predictions about the future using business forecasting and simulation. Accordingly, *predictive analytics* address the questions “what will happen?” and “why will it happen?” [33]. The questions “what shall we do?” and “why shall we do it?” fall within the scope of *prescriptive analytics*, which involves deriving optimal planning decisions given the predicted future [32].

The key objective of this work is to investigate the phenomenon of emerging in-memory analytics applications in SCM from two angles: first, we examine current focus and development areas of respective applications from a business perspective, and second, we delineate these applications in relation to extant information systems in SCM from an IT perspective. Consequently, we expand the framework into two directions using the disciplinary foundations of business analytics at the intersection of quantitative methods, decision-making, and technology, as described in Mortenson et al. [4]. The business perspective is structured along *use cases* and *methodological requirements* corresponding to the discipline of quantitative methods. We decided to add the use case dimension to ease application classification in Section 3. *DSS concepts* and *formal IT systems* constitute the IT perspective of the framework, corresponding to the disciplines of decision-making and technology. We explain the dimensions and mapping of the taxonomies in detail in what follows.

2.2. Use cases and methodological requirements

To the best of our knowledge, only Piller and Hagedorn [20] provide an overview of application patterns of in-memory data management systems. With respect to analytical applications, they identify four use cases: operational reporting, exploratory analysis of mass data, complex analysis, and adaptive planning. However, they only discuss exemplary applications that are motivated primarily by considerations in the ERP domain and do not deal with the specific requirements of SCM. We therefore generalized and extended their framework by surveying conceptual papers on ‘supply chain analytics’ that resulted from a structured literature search on titles, abstracts, and keywords. As a result, we distinguish four use cases of analytics applications in SCM: (i) monitor-and-navigate [22,34], sense-and-respond [22], predict-and-act [34,35], and plan-and-optimize [34]. The latter three use cases require a broad set of analytical methods beyond simple data aggregation such as data modeling and mining, (discrete-event) simulation, forecasting, and optimization [12].

Monitor-and-navigate use cases are concerned with periodic reporting and/or continuous monitoring of performance metrics as well as data drill-down to navigate root causes on a more granular level [1,22]. In the supply chain context, this includes location data from GPS and RFID tags to increase visibility into supply chain assets and material flows [34]. Data mining and modeling build the methodological foundation for reactive *sense-and-respond* use cases [22]. They help to discover

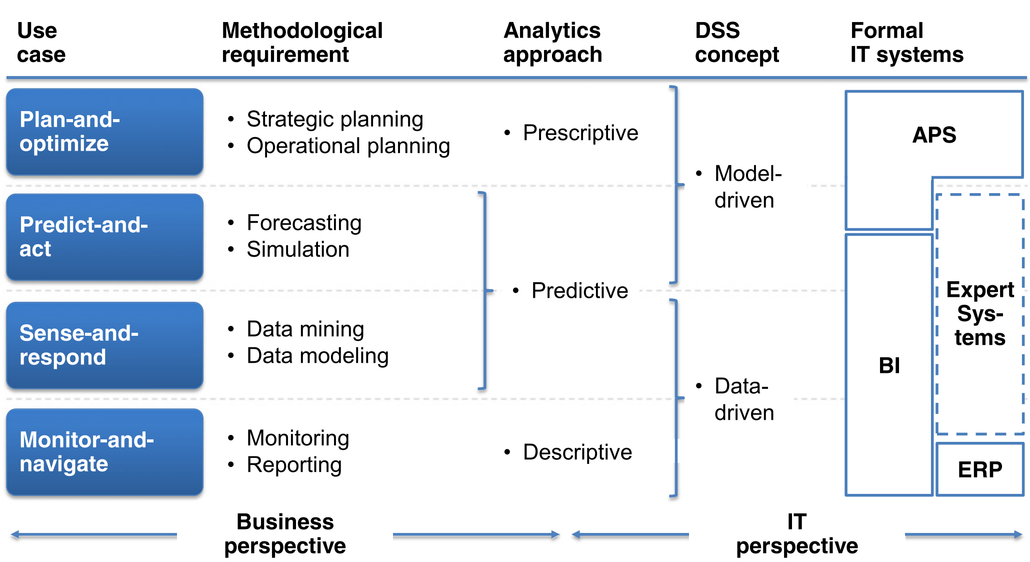

Fig. 1. A framework for analytics applications in SCM.