A JOINT MATURITY MODEL OF BI-DRIVEN SUPPLY CHAINS

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Abstract

Information technology (IT) and performance measurement are of rising value in globally connected supply chains. This results in the increasing implementation of business intelligence (BI) applications to enhance information exploitation as strategic and operational competitive advantages. To estimate the degree of maturity in supply chains as well as for BI solutions, maturity models are used. There exist numerous specific maturity models for supply chains, also in strong interrelationship with investigations on evolution stages of supply chains. Furthermore, certain BI maturity models are covering different perspectives to assess the degree of BI utilization in companies. The aim of this paper is two-folded. First, maturity dimensions should be isolated and extracted from given models. Second, a joint maturity approach by merging key dimensions of supply chain and BI maturity for BI-driven supply chains will be developed. In this context, BI-driven supply chains are a summarizing term for advanced supply chains in which efforts to base decisions on joint KPIs and metrics are strengthened as well as joint planning and collaborative forecasting activities are executed. Contribution to research is made by the combination of supply chain and BI maturity approaches.

Key words: Supply chain management, maturity models, business intelligence

1. INTRODUCTION

In times of increasing amounts of data from several sources like log and transactional data in supply chains or the deluge of unstructed online data (Sethuraman, 2012, p. 1), different techniques to handle and facilitate upcoming big data problems are approached. Especially in the domain logistics and supply chain management (SCM), the "collection and the exchange of data" (Garrido Azevedo et al., 2007, p. 8) are assessed as critical. Moreover, emerging information technologies (IT) as innovative solutions to improve overall process and performance quality in SCM (Hausladen et al., 2013, p. 166) are identified as momentous for "supporting cross-firm relationships" (Daugherty, 2011, p. 26). In the context of the later proposed research questions, the application of BI to face big data issues becomes crucial. Beside the generation of data in supply chains through telematics, logging data and data out of ERP and peripheral systems, the ability of collecting, processing and analyzing data to support decisions in supply chain management needs to be addressed. A recent survey among supply chain leaders revealed that only one third have implemented initiatives to handle big data problems yet (Cecere, 2013). Standards and models to combine IT and SCM aspects should therefore anticipate big data as an opportunity. Maturity models try to answer this question by evaluating these data-intensive domains, show the status quo of SCM and BI efforts and give implications for future developments.

Prior to express the specific research question of this paper, relevant terms need to be defined and delimitated. SCM „encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities“ (Council of Supply Chain Management Professionals (CSCMP), 2013, p. 187) including warehousing, distribution and after sales services with a strong focus on end-to-end value chains and customer requirements. To emphasize deeper on interorganizational issues, the domain logistics is therefore neglected in the forthcoming analysis since it follows a more operational focus (Hausladen et al., 2013, p. 164). Business intelligence is defined as an integrated and holistic approach which uses data from business transactions and beyond to generate and optimize business decisions (The Data

Warehousing Institute, 2014; Gendron, 2013, p. 4). Maturity models can be viewed either from a lifecycle perspective to achieve a final evolution stage by evolving over time or from a potential performance perspective, i.e. the maturity level is assessed and can be enhanced by doing certain improvements (Wendler, 2012, p. 1318). Basically, maturity models are a „sequence of maturity levels for a class of objects" (Becker et al., 2009, p. 213) which depicts a typical evolution path. According to Fraser et al. (2002), maturity models typically consist of a number of levels, a descriptor for and a generic description of each level, a certain amount of dimensions which are also broken down to a number of elements or activities containing detailed descriptions for each maturity stage (Fraser et al., 2002, p. 246). The evolutional stages are also the crucial element when delimitating maturity models from lifecycle approaches. A lifecycle shows different conditions during its steps as well as positive and/ or negative alterations by shifting from phase to phase, whereas stages in maturity models evolute in a positive way.

In this paper, we propose the following research questions:

(1) How far can we extract dimensions from maturity approaches in SCM and BI?
(2) Is it possible to map these dimensions and merge them into a joint maturity approach for BI-driven supply chains?

These research questions reflect the aims and also the structure of the aspired procedure. At first, maturity models in SCM and BI are presented in chapter 2. Then, the presented maturity models are analyzed in chapter 3 to isolate and extract key dimensions describing the individual maturity stages in the SCM and BI domain. Finally, a joint approach is suggested by mapping and merging dimensions from SCM and BI maturity models.

2. MATURITY MODELS IN SUPPLY CHAIN MANAGEMENT AND BUSINESS INTELLIGENCE

Numerous maturity models in SCM and BI have been constructed and proposed over years. Lahti et al. (2009) give a detailed overview over selected SCM maturity models and construct their own model based on prior analyses (Lahti et al., 2009). Concerning the BI domain, comprehensive compilations and analyses are provided by Raber (2014) (Raber, 2014) and Hribar Rajterič (2010) (Hribar Rajterič, 2010). Selected maturity models in SCM and BI are presented in the following, whereas the selection was based either on their popularity or on their relative ability to extract dimensions.

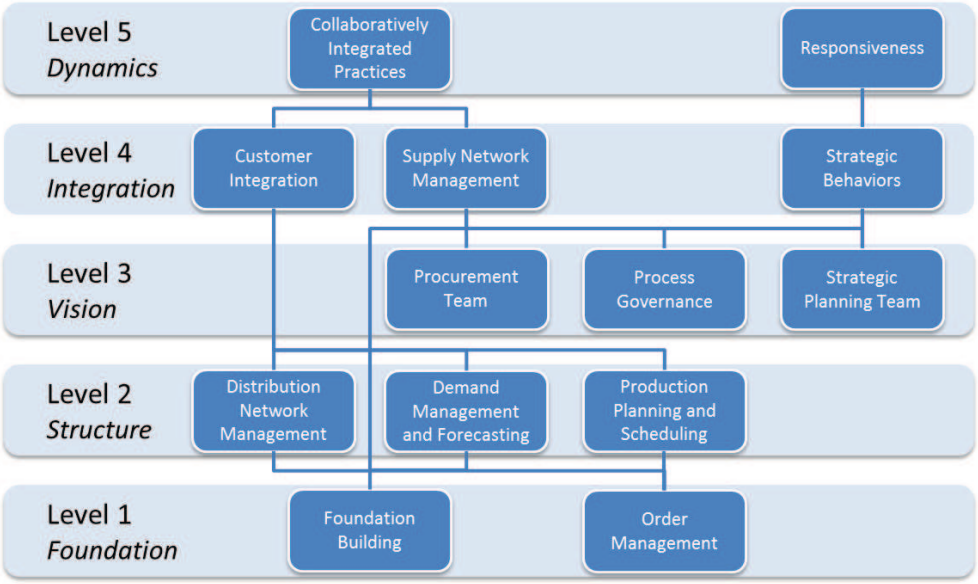
2.1. Maturity models in Supply Chain Management

Maturity models in SCM share the common idea of defining a certain amount of maturity levels which are also enriched with typical information and performance descriptions (Lahti et al., 2009, p. 657).

A common construct is the supply chain management process maturity model by Lockamy III & McCormack (2004), which is mainly based on business process orientation (BPO) concerning maturity improvements (Lockamy III & McCormack, 2004, p. 273). Influenced by the capability maturity model (CMM/ CMMI), the SCM maturity model consists of the five incremental stages Ad Hoc, Defined, Linked, Integrated and Extended, in which a textual description of the maturity condition takes place (Lockamy III & McCormack, 2004, p. 275). The SCM maturity model is conceptionalized toward SCM using the Supply Chain Operations Reference (SCOR) model. As proposed by Lockamy III & McCormack (2004), supply chain practices, that describe the execution of one or more processes (Supply Chain Council, 2012, p. 21), and procedures are purely viewed from a process perspective. Therefore, BPO maturity attributes organized in process views, structures, etc. and process capability measures like predictability or efficiency are taken into account to operationalize SCM maturity (Lockamy III & McCormack, 2004, p. 273).

Evolved out of the SCM maturity model, Oliveira et al. (2011) developed this approach further by integrating specific process groups into each maturity level. Although the model also consists of five stages, it follows an approach leaving the BPO layer and facing more toward a SCM view (Oliveira et al., 2011, p. 209). This is done by a Foundation level 1 maturity stage over the Structure and Vision stage, where the networks and processes should fully be managed. In addition, process groups describing integration (level 4 – Integration) and collaboration issues (level 5 – Dynamics) complete the maturity approach (Oliveira et al., 2011, p. 209). A special feature of this approach is the concrete application of a questionnaire comprising of 4-10 questions for every maturity process group each to apply the model and assess the current state of supply chain maturity (Oliveira et al., 2011, pp. 214–217). The maturity stages and the process groups are illustrated in Figure 1.

Figure 1 The Supply Chain Process Maturity Model by Oliveira et al. (2011)



Source: Oliveira et al., 2011, p. 209

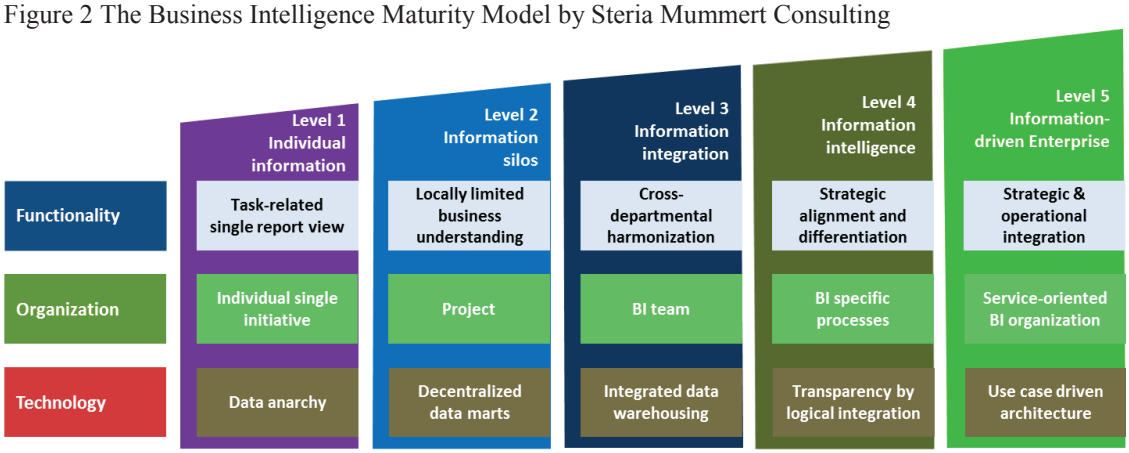
After analyzing six maturity models, Lahti et al. (2009) developed a four-stage maturity model which mainly focuses on integration issues and shows some similarities with the evolution path of supply chains in general (Stevens, 1989, p. 7). Nevertheless, the stages of Functional, Internal, External and finally Cross-Enterprise Integration are narrowed down to 16 sub-areas assigned to the four SCOR-oriented categories Plan, Source, Make, Deliver and additional Overall as a supply chain wide perspective (Lahti et al., 2009, p. 674). Like in the previous presented maturity model, a questionnaire with over 100 questions delivers the basis for assessing the maturity level. Furthermore, by using the questionnaire assessment and concrete sub-areas, implications on dominant or current and future practices as well as benchmarks when comparing different organizations can be given (Lahti et al., 2009, pp. 671–674).

2.2. Maturity models in Business Intelligence

Maturity models in IT and especially in the area of BI are gaining some widespread attention. In comparison with maturity models in SCM, research begun a decade earlier and generate concrete models and even international standards like CMM/ CMMI, SPICE or COBIT. Therefore, these models are far more developed and refined.

A detailed maturity model tailored for BI is the biMM (Business Intelligence Maturity Model) by Steria Mummert Consulting, which is also used to present the annual status quo of BI in Europe (Dittmar et al., 2013). In this model, five levels with a strong information background span the range of maturity characterized by the three dimensions functionality, organization and technology, which is completely illustrated in Figure 2. For every dimension, the stage of maturity is assessed by a relevant set of elements or activities for each element. For instance, service-oriented BI organization (dimension organization at maturity level 5) is described by continual process improvements or best-fit-sourcing among others (Dittmar et al., 2013, p. 26).

Figure 2 The Business Intelligence Maturity Model by Steria Mummert Consulting



Source: Dittmar & Oßendoth, 2013, p. 7

Another seminal model is the BI maturity model developed within The Data Warehousing Institute (TDWI). This approach divides the maturity of BI into the five stages Nonexistant, Preliminary, Repeatable, Managed and Optimized, refined by the eight key dimensions scope, sponsorship, funding, value, architecture, data, development, and delivery (Gonzalez, 2012, p. 3). A specialty of TDWI's maturity model is the integration of two certain barriers between stages, in particular the Gulf between the Nonexistent and Preliminary and the Chasm between the Repeatable and the Managed stage. In the model, advice and challenges are compiled to successfully overcome these barriers and reach the next stage (Gonzalez, 2012, pp. 3–10).

As detected by Tan et al. (2011), enterprise-wide BI initiatives as well as their maturity assessments are limited in research. Seizing this gap, they propose a Maturity Model of Enterprise BI, which is, from a maturity stage's point of view, based on the CMM/ CMMI approach and consists of the five stages Initial, Repeatable, Defined, Managed and Optimizing (Tan et al., 2011, pp. 1–3). The maturity model aspires a more IT-related direction and uses the four dimensions information quality, master data management, warehousing architecture and analytics to describe the different maturity levels in detail (Tan et al., 2011, pp. 4–5).

By contrast, Ong et al. (2011) developed a BI maturity model with respect to an organizational perspective after analyzing different BI maturity models. This was done by reviewing, matching and reducing especially the dimensions of five different maturity models to four basic dimensions and arrange them on a not otherwise specified five-stage maturity scale (Ong et al., 2011, p. 3).

3. MAPPING OF SCM AND BI MATURITY MODELS

Dimensions provide a characteristical structure to maturity models and are commonly seen as specific capability areas which are structuring fields of interest and describing different issues of the maturity assessment's object (Lahrmann & Marx, 2010, p. 522; Raber, 2014, p. 64). They are determined and detailed by practices, measures or activities at each stage of maturity (Fraser et al., 2002, p. 246). The aim of this analysis is to extract maturity dimensions from both perspectives SCM and BI and merge them into a joint maturity approach.

3.1. Extraction of key dimensions from SCM maturity models

As seen in 2.1, the maturity model proposed by Lockamy III & McCormack (2004) is based on a BPO approach. Here, several process maturity attributes like process view or structures are introduced, which are explained in Table 1. Furthermore, the four detailed process goals predictability, control, effectiveness and efficiency as marking thresholds between maturity levels are suggested (Lockamy III & McCormack, 2004, p. 274).

By contrast, Oliveira et al. (2011) use no specific dimensional approach and orient their maturity scale on a set of process groups which also stand for achieved or to-be conditions in the respective maturity stage (Oliveira et al., 2011, p. 209).

While Lockamy III & McCormack (2004) used the SCOR model only cursory to conceptionalize their maturity model, Lahti et al. (2009) expand a part of its major processes Plan, Source, Make and Deliver to a dimensional maturity approach, which is also depicted and explained in Table 1.

Table 1 Summary of dimensions in the field of SCM maturity models

Author	Dimensions	Explanation
Lockamy III & McCormack (2004)	• Process view • Process structures • Process jobs • Process measures • Process values	• Process definition and documentation • Teams, collaboration and integration • Ownership, authority and influence • Definition, ownership and linkages • Customer focus, credibility and trust
Oliveira et al. (2011)	• Process groups	• Varied process groups which show different tasks in maturity
Lahti et al. (2009)	• Plan • Source • Make • Deliver • Overall	• Strategy, demand and supply planning • Sourcing and supplier management • Manufacturing and scheduling processes • Order and warehouse management • Supply chain metrics and developments

Source: Lockamy III & McCormack, 2004, p. 274; Oliveira et al., 2011, p. 209; Lahti et al., 2009, p. 674

3.2. Extraction of key dimensions from BI maturity models

As mentioned above, maturity models in BI are much more advanced comparing to SCM. This is also reflected concerning the elaboration of maturity dimensions. In biMM, three dimensions differentiate the view of maturity into a business or content-related (functionality), a structural (organization) and a BI-specific perspective (technology). Within functionality, the validity of the content delivered by the BI application is tested and verified as well as the usability and the degree of decision and analytics process support. The organizational dimension addresses the embeddedness of the BI application in a process and procedure structure of a company, therefore also the degree of institutionalization and formalization. Furthermore, strategic and economic aspects of BI initiatives are depicted. Finally, flexibility, quality and technical functionality of the realized BI solution are reflected through the technology perspective, which is also considering the data architecture and the degree of standardization or customization (Dittmar et al., 2013, p. 68).

TDWI's BI maturity model arranges its maturity levels around eight dimensions, which are shown in detail in Table 2.

Table 2 Dimensions of TDWI's BI maturity model

Dimension	Explanation
Scope	To what extent does the BI/ (data warehouse) DW program support all parts of the organization and all potential users?
Sponsorship	To what degree are BI/ DW sponsors engaged and committed to the program?
Funding	How successful is the BI/ DW team in securing funding to meet business requirements?
Value	How effectively does the BI/ DW solution meet business needs and expectations?
Architecture	How advanced is the BI/ DW architecture, and to what degree do groups adhere to architectural standards?
Data	To what degree does the data provided by the BI/ DW environment meet business requirements?
Development	How effective is the BI/ DW team's approach to managing projects and developing solutions?
Delivery	How aligned are reporting/ analysis capabilities with user requirements and what is the extent of usage?

Source: Gonzalez, 2012, pp. 10–11

Following a more technical lane, Tan et al. (2011) structure their BI maturity model by means of four dimensions. The dimension of information quality incorporates all aspects concerning data and resulting information quality. Master data management addresses issues like access and business rules and an enterprise-wide data convergence. The design of analytics services within the company, evolving from spread marts to enterprise-wide services, is addressed through the dimension warehousing architecture. Lastly, the dimension analytics describes the capability of shifting analytical efforts toward a competitive factor (Tan et al., 2011, pp. 4–5).

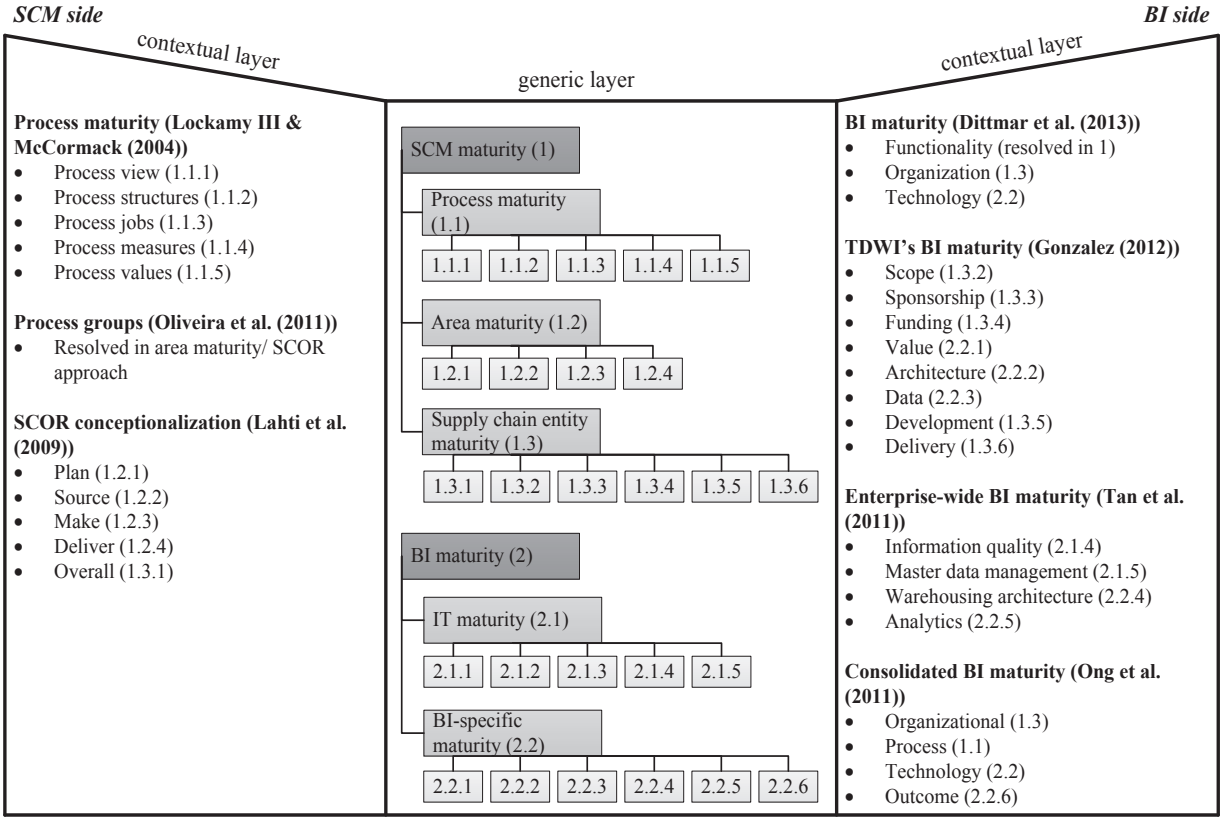
To conclude with a broader view, Ong et al. (2011) propose four consolidated dimensions. Whereas the organizational dimension includes elements like vision, goals, scope, governance, training and strategic alignment, the process dimension covers change and data management as well as data governance and implementation issues. Data warehousing and the application of certain technology types like OLAP are included in the technology dimension. Finally, the dimension of outcome aims at the resulting data and information quality expressed in metrics and KPIs (Ong et al., 2011, p. 3).

3.3. Mapping the key dimensions to create a joint maturity approach

Given that the amount of data in supply chains in steadily increasing and big data issues are heavily discussed in research and practice, we propose a paradigm shift from common supply chains to BI-driven supply chains to face this development. According to CSCMP (2013), supply chains refer to material and information linkages and interchanges starting with raw material and ending with final customers (CSCMP, 2013, p. 186). We need to emphasize further on information generation and data exploitation involved in supply chain decisions to enhance supply chains toward more agility. A cornerstone of these activities may be a joint maturity approach combining SCM and BI dimensions.

After the extraction of maturity dimensions took place, the dimensions out of the SCM and BI perspective should be mapped using a hierarchical dimension approach. Here, we constructed a model consisting of two contextual layers (SCM and BI side) and merge the given maturity dimensions into a generic dimensional layer for a joint maturity model of BI-driven supply chains, which is illustrated in detail in Figure 3. As we have identified different hierarchical levels of maturity dimensions, some dimensions from the used maturity models are partly resolved in new generic dimensions or in the first hierarchical levels (e.g. (1.3) supply chain entity maturity). To avoid overlaps concerning the SCM and BI side, all organizational and functional/ content-related dimensions coming from the BI side were integrated in the dimension of supply chain entity maturity, which reflects the supply chain as a holistic contruct. Thus, a distinction between supply chain areas like Source and the supply chain as a construct was done as well. Concerning BI maturity in the joint model, it is necessary to assess IT maturity like information quality likewise since it provides a substantial requirement for BI maturity. A clean separation of SCM and BI dimensions is therefore inevitable to reflect a deep application of one technical approach within an organizational construct.

Figure 3 A dimensional maturity framework for BI-driven supply chains



Source: own illustration

The overall intent of the mapping approach is to create a joint perspective of BI and SCM maturity since previous maturity investigations were only undertaken in an isolated way. Likewise, business processes and the corresponding IT infrastructure are often designed and implemented without addressing the relations between them (cp. Hausladen, 2014, pp. 236-237). By using this approach, the functional – supply chain management and its processes – and the technical perspective – IT and its structure – should be combined. This can be executed by choosing a cross-functional project team to assess and enhance the maturity of a BI-driven supply chain. Here, focal companies, if existing, take over an important role to foster the practical implementation of the proposed approach.

4. CONCLUSION

In this paper, we show the diversities of maturity models in SCM and BI. To construct a joint framework for the maturity of BI-driven supply chains and successfully answer the prior proposed research questions, the dimensions structuring the maturity approaches are firstly extracted and secondly mapped within a single framework. Concerning SCM maturity, a focus on a SCOR- and process-based evaluation was revealed during the analysis. By contrast, maturity models in BI are far more developed, therefore a bigger set of dimensions was extracted and dominance of BI maturity was detected. However, a joint dimensional maturity framework for BI-driven supply chains was develolped on a theoretical basis by using hierarchies among dimensions and a separation into a content- and process-related and a technical perspective.

To follow a holistic approach, further research activities could be activated by picking up the suggested framework, creating a robust questionnaire for each detailed dimension in every second level and execute an industry survey among enterprises linked in the same supply chain to firstly validate the maturity model and secondly apply it in practice. To enhance this practice, different supply chains could be surveyed and benchmarked. Moreover, relationships between information and supply chains should be deeper analyzed to leverage a concept of BI-driven supply chains.

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