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A survey on supply chain ontologies

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Abstract:

Nowadays, the business area cannot be sustainable and efficient without the presence of the Supply Chain. However, Supply Chain Management is by no means an easy task. Experts, in their effort to achieve the most efficient Supply Chain Management, have turned their attention to the management of knowledge related to supply chains. Thus, they model the concepts and the semantic relationships between them in Supply Chain Networks and create conceptual models and ontologies. In this paper, a survey of the existing ontologies in this field is carried out, with the aim of creating a new ontology of the Supply Chain that will unify its structural elements and lead to the integration of all supply systems. For this purpose, 22 ontological models from different supply systems, from over 90 sources, have been collected, briefly presented and commented on. These models, although being an intersection in the effort to model business operations and delineate a good basis for businesses to engage in Logistics processes, they lack an adequate formulation of appropriate semantics and terminology to describe all the different functions of the Supply Chain. Consequently, this lack inevitably leads to incompatible interpretations and uses of the knowledge that results from intercompany transactions.

Key words:

Supply chain, logistic, conceptual modeling, ontology, integration.

1. Introduction

The development of Supply Chain has contributed to the rapid movement of goods from all over the world, helping to improve the quality of life of consumers by increasing the variety of goods, ensuring their quality and availability, and offering them at better prices through better resource management and consequent cost reduction. However, Supply Chain Management is becoming increasingly difficult, since due to the development of technology and the increase in requirements, the complexity of interactions and flow mechanisms within its structures is constantly increasing. For a decade now, experts have been proposing a conceptual understanding of the Supply Chain to address this problem (Marra et al., 2012; Samuel et al., 2011). That is, businesses need to conceptually understand the basic structural elements of their supply chain, in order for their company to be sustainable and efficient.

In addition, many researchers argue that the key word for an effective Supply Chain is “integration” in managing the flows between all stages of the supply chain (Chaudhuri et al., 2018; Prajogo and Olhager, 2012; Lambert et al., 1999). Only in this way will the company be able to fully control its activities, limiting costs and improving customer service levels, at the same time. Of course, this total system

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approach presupposes an understanding of every activity and function that takes place in the Supply Chain in relation to its interaction with other elements of the chain. The idea is that the result of a series of activities, where interdependencies and interactions are taken into account, is better than the sum of the individual results of the individual activities. In order to meet this need for integration, many researchers and groups, such as the Supply Chain WG (working group) of the organization Industrial Ontologies Foundry (https://industrialontologies.org/supply-chain-wg/), have attempted to create, extend and integrate ontologies into existing models or create Domain Specific References Ontologies. The usefulness of an ontology is derived from the understanding of activities throughout the Supply Chain. Through the understanding and creation of an ontology, the Supply Chain Management will be able to address the continuously increasing difficulty of the Supply Chain's complexity.

2. The concept of logistics and supply chain

For the term "Supply Chain" there are many definitions in the international literature, depending on the point of view and the purpose on the basis of which each expert or researcher approaches its concept. However, all definitions converge in that the Supply Chain (SC) is a process that runs through a flow of materials and a reverse flow of information, as can be seen in the definition of Stevens (1989), who argues that the SC is a linked series of activities, a system whose constituent parts include production facilities, material suppliers, distribution services and customers linked together by the "forward" flow of materials and the "backward" flow of information. In particular, SC is an integrated process of planning, applying, and controlling essential processes (Lambert, 2004), a network of connected entities (Harland et al., 2001) that produces and adds value in the form of products or services in the hands of the end-consumer (Christopher, 1992; Mentzer et al., 2001), supporting him even after the sale of the products with the aim of preserving them (Marbert and Venkataramanan, 1998) (see: Green Logistics, Reverse Logistics, Closed-loop Supply Chain). In this context, the goal of all companies is the sound and sustainable Supply Chain Management, a subset of which is Logistics (Hellenic Logistics Society, 2005), although various opinions have been expressed regarding the relationship between Supply Chain and Logistics (for these opinions see: Larson and Halldorsson, 2004). Logistics plan, implement, monitor and control the efficient and effective normal flow, reverse flow and storage of products, services, and related information from the original/source point to the consumption point, in order to meet the requirements of customers (CLM, 1998), who can create "value" themselves, turning the Supply Chain into a Demand Chain. Logistics has a wide range of application areas and includes activities and functions related to logistics network planning, transport and distribution management, vehicle fleet management, warehousing, material and inventory management, execution of orders, planning of supply/demand, management of third-party logistics (3PL) and IT-telematics. To some extent, its function is also related to the design and planning of procurement and production, assembling and packaging as well as customer service/support. Thus, it is involved in all levels (strategic, operational, and tactical) of planning and execution, since its purpose is to transport the right product, in the right quantity, in the best condition, and at an acceptable cost, according to the Chartered Institute of Logistics and Transport (CILT; https://ciltuk.org.uk/), in order to achieve - through the management of flows between all stages of the supply chain - the maximization of added value with the simultaneous minimum cost, as well as the optimization and sustainability of the Supply Chain through the application of Reverse Supply Chain (Papakitsos, 2021). Therefore, justifiably, Supply Chain Management is now considered synonymous with a new term, the so-called "Advanced Logistics" (OECD, 1996).

3. Methodology and results of the survey

The review of the bibliography in the field of Supply Chain Management, but also of Supply Chain Knowledge Management is of primary importance for anyone who aims to create an ontology that will achieve the integration of the entire supply chain network system. Thus, the authors of this paper, aiming to create a new ontology in Greek terminology, began their research by studying the pre-existing ontologies (all in the English language, in the absence of ontologies in Greek), aiming at the unification of elements and the integration of systems to optimize each domain in which the ontology will be used. The methodology followed was that of *systematic literature review* (SLR).

3.1. Systematic Literature Review

SLR identifies, selects and critically evaluates research in order to answer a clearly formulated question (Dewey & Drahota, 2016). A systematic review should follow a clearly defined protocol or plan, where the criteria are clearly stated before the review is conducted. It is a comprehensive, transparent search, conducted across multiple databases and gray literature that can be replicated by other researchers. It involves planning a well-thought-out search strategy that has a specific focus or answers a defined question. The review identifies the type of information sought, judged and reported within known time frames. Search terms, search strategies and boundaries should be included in the review.

Pittway (2008) outlines seven key principles behind systematic literature reviews: Transparency, Clarity, Comprehensiveness, Focus, Equity, Accessibility and Coverage. These principles apply when using search engines, which are powerful literature review tools. However, there are differences between these sources and care is needed to ensure that all relevant data are collected. Inclusion and exclusion of studies found in the literature search must strictly adhere to the selection criteria defined accordingly, to answer the predefined questions and/or objectives of the review. Although not always feasible, two independent reviewers should conduct the systematic literature review and subsequent data evaluation. This would further reiterate the importance of detailed rationale and a well-communicated record of inclusion criteria. Rejected studies should be recorded and any disagreement between reviewers should be resolved by a third party, preferably a supervisor. So, the main points of the relevant process are (Piper, 2013):

- Systematic review allows rigorous, unbiased and bibliographic assessment of study outcomes, quality and design.

- Poorly conducted systematic reviews can be misleading, just like any other experimental study.

- A vague question is likely to lead to a vague answer.

- When searching the literature, care must be taken to ensure that all relevant data is collected.

- A thorough search must be combined with meticulous record keeping.

- To be able to criticize the quality and limitations of the literature, in order to improve the design of the future study.

- To provide for the recording of the new findings that the review brings to the literature.

Systematic literature reviews originate from medicine and are linked to evidence-based practice. According to Grant & Booth (2009), the expansion of evidence-based practice has led to an increasing variety of review types. They compare and contrast 14 review types, listing the strengths and weaknesses of each. Tranfield et al. (2003) discuss the origins of the evidence-based approach to conducting literature review and its application to other scientific disciplines, including management science and business research. However, due to the diverse nature of research fields outside the natural sciences, the aforementioned methodological steps cannot be easily applied to all areas of business research. Efforts to transfer processes from medicine to business research include a step-by-step approach (Durach et al., 2017), developing a standard procedure for conducting systematic literature reviews in business and finance.

3.2. Existing ontologies in Supply Chain and Logistics

Although in the field of Supply Chain there is not much research work on ontologies, as it comparatively happens in medicine, biology, telecommunications, etc., yet, there are some notable works, the study of which led to important conclusions. In particular, many scholars attempted the creation, extension and integration of ontologies into already existing models and many individual ontologies have been adapted to the field of Supply Chain Management and, particularly, in the field of Supply Chain planning (Chandra and Tumanyan, 2007), in the area of production, design, product manufacturing and product lifecycle management (Obitko and Marík, 2002; Huang et al., 2005; Lemaignan et al., 2006; Lin and Harding, 2007; Hepp, 2008; Bruno et al., 2015) or storage planning (Weber et al., 2019), in the sector of negotiations in the global manufacturing (Jiao et al., 2006) or in the area of suppliers and transport providers (Achatbi et al., 2018), in e-commerce (Tamma et al., 2005; Cao et al., 2015), in the field of transport, national or cross-border (Merdan et al., 2008; Ponanan et al., 2017; Dorofeev et al., 2020), in the domain of cooperation of 3PL companies in transport (Memon et al., 2014), in the field of Co-operative Supply System (Smirnov and Chandra, 2000), in the field of providing logistics services (Glöckner et al., 2017), in decision-making (Ha et al., 2008; Muñoz et al., 2011), for supplier selection (Yiqing et al., 2009), for waste treatment (Muñoz et al., 2013) or for emergency logistics distribution cases (Zhang, 2013), in the field of product tracking (Vikram et al., 2003), of delivery service management in logistics (Sivamani et al., 2014), of monitoring business partners in a supply network (Yu-Liang, 2010), in the field of e-business, e-commerce and e-logistics in general (Haugen and McCarthy, 2000; Ontoweb Ontology-Based Information, 2002; Foxvog and Bussler, 2005; Lee et al., 2006; Leukel et al., 2006; Blaj et al., 2020), in the sector of mass customization (Pawlaszczyk et al., 2004), in information flows (Lu et al., 2012), in the integration of Supply Chain flows (Gonnet et al., 2006) and, more generally, in the field of enterprises (Fox et al., 1996; Uschold et al., 1998; Soares et al., 2000; Madni et al., 2001; Ye et al., 2008). Below, the most important ontologies are presented in the field of business and the Supply Chain, with a focus mainly on the entities (by the term "entity" is meant the concepts that make up the classes or sub-classes of the ontology) and the relationships between them that they include, depending on their purpose, methodology, and domain, in an effort to highlight the common concepts that exist in capturing the terminological knowledge of the Supply Chain and on which the new ontology is based, unifying and completing the previous knowledge. Thus, the most important ontological models of Knowledge Management in this area are the following:

[1] The ***Enterprise Ontology*** (Uschold et al., 1998) attempts a business modeling, by developing the following five basic sections: (1) Meta-Ontology and Time, (2) Activity, Plan, Capability and Resource, (3) Organization, (4) Strategy, and (5) Marketing.

[2] The ***TOVE*** (Toronto Virtual Enterprise) ***Ontologies*** (Fox et al., 1996), aiming at the modeling of tasks in industrial environments, include a set of ontologies depending on the respective basic entity: (1) the Resource Ontology (Fadel et al., 1994), (2) the Cost Ontology (Tham et al., 1994), (3) the Organization Ontology (Fox et al., 1996; Fox et al., 1998), (4) the Product Ontology (Lin et al., 1996), (5) the Activity-State-Time Ontology (Fox and Gruninger, 1998), and (6) the Ontology for Quality Management (Kim et al., 1999).

[3] The ***Model by Soares et al.*** (Soares et al., 2000), developed with the aim of improving human communication and defining the requirements for production planning and its control in the virtual environment of a company, is an ontology that includes three basic sections: (1) Networked/ Extended Organizations, (2) Plans, and (3) Orders Management.

[4] The ***IDEON*** ontology (Madni et al., 2001), which provides the basis for designing, reinventing, managing, and controlling distributed and collaborative enterprises, includes four aspects that aim to capture different relationships and concepts that describe an enterprise: (1) the Enterprise Context View, (2) the Enterprise Organizational View, (3) the Process View, and (4) the Resource/Product View.

[5] The ***Manufacturing System Engineering*** (MSE) ***Ontology*** (Lin et al., 2004; 2007), developed to support the implementation of an MSE Moderator in the environment of an extended virtual enterprise, has the following seven high-level classes arranged in a hierarchy of sub-classes: (1) Project, (2) Flow, (3) Process, (4) Enterprise, (5) Extended_Enterprise, (6) Resource, and (7) Strategy.

[6] The ***Model by Ye et al.*** (Ye et al., 2008) was developed to achieve a "semantic integration between heterogeneous information systems in a supply chain" and includes the following high-level classes: (1) Supply_Chain, (2) SC_Structure, (3) Party, (4) Role, (5) Purpose, (6) Activity, (7) Resource, (8) Transfer_Object, (9) Performance, and (10) Performance_Metric.

[7] In **Huang et al.** (2003) supply chain knowledge includes the following six categories: (1) Product, (2) Process, (3) Resources, (4) Inventory, (5) Order, and (6) Planning.

[8] In **Smirnov and Chandra** (2000) the authors create an ontology in the field of the Co-operative Supply System and they are based on the common knowledge model of Supply Chain: "product – process – resources".

[9] In Pawlaszczyk et al. (2004), the ***MC Ontology*** (Mass Customization Ontology) is proposed, which includes as basic concepts the following: Strategies, Purpose, Plans and Processes, Activities, Product, Components and Modularization-Schemes, Customer profile, Transfer Objects and Flows, Interfaces, Decoupling Point, Actors, Supply Chain Network, Performance Attributes and Metrics.

[10] The authors in Geerts and O'Leary (2014) have created the ***EAGLET*** ontology, in order to achieve a Highly Visible Supply Chain (HVSC), which incorporates three different perspectives: (a) the physical flow, (b) the chain of custody, and (c) the chain of ownership, and includes the following five primitive entities: (1) Event, (2) Agent, (3) Location, (4) Equipment, and (5) Thing.

[11] Large percentage of authors (Fayez et al., 2005; Ureten and Ilter, 2006; Leukel and Kirn, 2008; Sakka et al., 2010; Sakka et al., 2011; Lu et al., 2012; Haller et al., 2008; Yiqing et al., 2009; Zdravković et al., 2010) create methodologies and ontologies in the context of managing business activities based on the ***SCOR*** model (Supply Chain Operations Reference model), which is one of the most well-known business reference models (Huang et al., 2005; Roder and Tibken, 2006) that provides a terminology and standardized procedures. The SCOR model at the level of strategy is based on five basic entities: (1) *plan*, (2) *make*, (3) *deliver*, (4) *return*, and (5) *source*. SCOR, of course, allows a general description of Supply Chain activities and their translation into process maps but it does not attempt to describe every business activity or process, including the flow of data between them. In other words, it describes processes and not functions, which means that it does not refer to the activities involving persons.

[12] In ***Hoxha et al.*** (2010) and ***Scheuermann and Hoxha*** (2012), where an approach to achieve flexibility and "decentralization in supply chain configuration and management" is presented, the authors define top-level ontologies for the entities: (1) process, (2) service, (3) resource, and (4) service level parameter.

[13] The authors in ***Daniele and Pires*** (2013) propose a core-ontology that explicitly defines the main concepts adopted in the field of logistics and is built on the following fundamental concepts: (1) Activity, (2) Actor, (3) Physical Resources, (4) Location, and (5) Time.

[14] The authors in ***Hendi et al.*** (2014) made an optimization ontology attempt, with the aim of standardizing a general product design improvement cycle, relying on previous optimization ontologies, such as SoPT (Han et al., 2011), ONTOP (Witherell et al., 2006) and GOO (Moussas et al., 2013), which include as upper-level classes the concepts of: process, resource, service, performance, activity, supply chain, and logistic problem.

[15] The authors in Kumar and Park (2010) developed an ontology, ***Know-Ont***, using Protégé and the SPARQL query language, for managing knowledge within an enterprise. Even in this ontology the basic entities are: (1) Activity, (2) Person, (3) Physical Circumstances, (4) Time, (5) Location, (6) Artefact, and (7) Resources for the actual production of the product.

[16] In ***Xu et al.*** (2011) the authors, proposing an intelligent external logistics monitoring system, consider the following entities as the basic activities of the logistics process: delivery, warehouse, order/forecasting, planning, transportation, information and data, and as main factors in the logistics environment the entities: sender, receiver, and logistics service provider.

[17] The authors in Anand et al. (2012; 2016) created the ***GenCLOn*** ontology in the field of City Logistics, which includes eight main classes: (1) 'Stakeholder', (2) 'Objective', (3) 'KPI' for the measurement of the degree of achievement of objectives, (4) 'Resource', (5) 'Measure', (6) 'Activity', (7) 'R&D' which acts as a "library index", and (8) 'Value_partitition' which includes the entities that cannot be categorized into the previous seven classes.

[18] The authors in Koç et al. (2014) develop an ***Ontology for Trailer Surveillance (OTS)***, aiming to improve information flow, based on information content, location, time of delivery, quality, and presentation, in which the following are defined as basic classes: (1) Event, (2) Feature, (3) Phenomenon, (4) Observation, (5) Sensor, and (6) Situation.

[19] In Engel et al. (2014), the authors propose the architectural design of a Supply Chain Management platform based on ontology, the ***i-Supply Ontology***, in order for professionals to be able to reuse supply chain knowledge for planning, design, and management of its structures. The knowledge base has as its core the *i-Supply Ontology*, which can be further categorized into three individual ontologies: (a) the supply chain, which includes the concepts: purpose, activity, resource, structure, and the relationships between them, (b) the context ontology that captures concepts specific to the project and its environment, such as: project, domain, stakeholders and geography, and (c) the logistics ontology, which further extends the concepts of the supply chain ontology through relationships with concepts like: transportation, storage and human resource.

[20] In ***Glöckner and Ludwig*** (2017), the authors develop an ontology structure in the field of logistics services, supporting the digitized collaboration of various providers and enabling cloud logistics. In the logistics service map, they create three key concepts: (1) Condition of goods and customer requirements, (2) Functional Character, and (3) Dimension.

[21] The authors in ***Negri et al.*** (2017), evaluating twenty-six (26) ontologies and observing that most of them focus on processes, present a system in the field of manufacturing that extends the Manufacturing Systems Ontology (MSO) (Strzelczak et al., 2015), focusing more on resources and not on processes. The basic idea is based on a "sub-system", i.e., on the gathering of resources. Subsystems are composed either by other subsystems or by components, which are connected to each other by hierarchical inheritance relationships. In particular, the "component class" includes: (1) "Processors" that perform transformation processes, (2) "Transporters" that handle and transport parts or materials, (3) "Storages" that store parts and materials, (4) "Unit loads" (UL) which are the basic handling units, (5) "Tools" which are required to perform functions, and (6) "Fixtures" which include the tools.

[22] Extending the previous research of Negri et al. (2017) to other ontologies (a total of 67), the authors in ***Knoll et al.*** (2019), in an attempt to merge and integrate the existing ontologies in the field of internal logistics and aiming at data mining, they designed a new ontology, in which as higher classes, in fact, sub-classes of the higher entity "Thing", they have considered the objects: Process, Resource, UnitLoad, Actor, and CustomerOrder.

3.3. Results of the survey

The study of the above ontologies and the related to them papers and reviews lead to conclusions, the most important of which are the following:

1) All work related to Supply Chain ontology focuses on "the organization and structure of human knowledge" about the supply chain and not on understanding the reality of supply chains, with the result that all the methodological approaches adopted are far removed from the reality of SC itself (Grubic and Fan, 2010).

2) The existing ontologies aim to provide some basic concepts of specific logistics systems and not to provide a sufficient set of concepts and interactions in relation to the real complexity of logistics systems, which means that each ontology focuses on a different level of detail and abstraction since it also serves a different purpose. Thus, the ontologies focus partially on logistics concepts (e.g., process, deliver, return), without any comprehensive view of the entire field.

3) The issue of the ontological representation of the Supply Chain is mainly addressed either from the perspective of "resources", i.e., the resources and means required for the flow of the chain, or from the perspective of "processes", i.e., the procedures required for supply chain operation (Negri et al., 2017; Knoll et al., 2019). Most follow the second case, defining the relationships that exist between these activities. Consequently, a static and limited perspective on the supply chain field prevails, while detailed analysis is found only at the strategic level (Grubic and Fan, 2010).

4) Much work has been published in the area of product manufacturing and production, as opposed to the area of internal logistics. Of the twenty-six (26) ontologies examined by the authors in (Negri et al., 2017), only two (2) focus on internal logistics and warehousing, while the remaining twenty-four (24) focus on the supply chain. Therefore, there is a lack of a comprehensive ontology that refers to internal logistics and, specifically, to the field of warehousing (Negri et al., 2017; Knoll et al., 2019), as well as a clear definition of the traceability of material and services (Grubic and Fan, 2010).

5) According to (Knoll et al., 2019), the existing ontologies in the area of internal logistics are not yet complete due to: (a) the partial focus of the ontologies without a comprehensive consideration of processes and resources, (b) the different level of detail and abstraction of each ontology, (c) incomplete standardization of the classification, and (d) incomplete integration of existing higher ontologies. Most ontologies (42 out of 67 evaluated by the authors) describe as basic entities the concepts: (1) resource (e.g., storage, transfer), (2) process (e.g., activities), and (3) actors (e.g., customer). Also, the concepts of load unit, product, part, logistics operations and activities, location, and time are often mentioned.

6) In the thirty-three (33) ontologies studied in this paper, the predominant entities used in the

ontologies related to Supply Chain Management are: Resources (14%), Process (9%), Human Resources (8%), Plan (8%), Activity (7%), Product (6%), Performance (4%), Order (3%), Flow (3%), Purpose (2%), while entities such as Inventory, Cost, Marketing, Warehouse, Service are not so often encountered, which are nevertheless equally important for the operation of the Supply Chain, as shown in Figures 1-2.

7) The structure of taxonomy and classes prevails (Grubic and Fan, 2010), but there is no standardization in the classification for equivalent objects and for object and data properties.

8) Ontology is reduced to simple terminological problems (Grubic and Fan, 2010), while at the same time inconsistent and confusing terminology of ontology structures, as well as a lack of ontological clarity, is observed.

9) We are far from using ontologies to solve information systems interoperability issues (Grubic and Fan, 2010), and, consequently, ontologies are not treated with the required maturity. There is a lack of integration of the existing ontologies, with the result that each ontology describes the concepts in a different way.

10) Empirical research must be expanded to establish the theoretical background for Ontology Engineering in the field of Supply Chain Management (Scheuermann and Leukel, 2014).

From the above, the problems that exist in the area of ontologies for Logistics can be clearly seen. The models that have been developed for the Supply Chain are certainly an intersection in the effort to model business operations and delineate a good basis for businesses to engage in Logistics processes, but they lack an adequate formulation of appropriate semantics and terminology to describe all the different functions of the Supply Chain. This lack inevitably leads to incompatible interpretations and uses of the knowledge resulting from inter-company transactions. Thus, the creation of a new ontology in the field of Supply Chain, and in particular in internal logistics where there is no completeness, responds to the absence of a classified comprehensive presentation of the basic concepts of the Supply Chain, while the necessity of unifying and integrating all of the existing knowledge requires the creation of an ontology from scratch.

4. Conclusion - Future Perspectives

The above survey demonstrates the major difficulties faced by the field of Supply Chain Management, as well as the problems that exist in the field of its conceptual representation related to ontologies. The results from 22 ontologies lead to 10 findings, clearly confirming that the field of Supply Chain ontology is heavily fragmented and in need of a new ontology that will include the Supply Chain as a complete system, instead of a set of individual sub-systems, each of them with their own ontology.

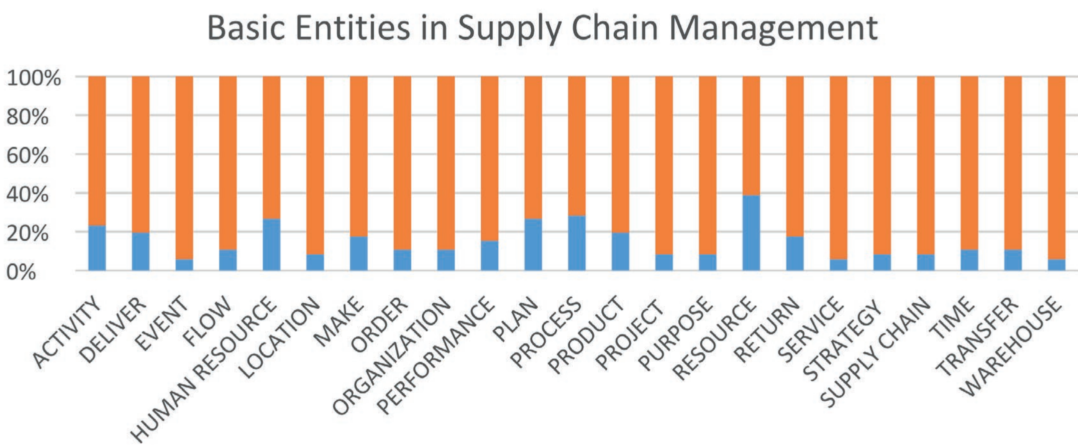

Figure 1. Stacked bar graph to compare the frequency of annotated entities in Supply Chain ontologies; *Horizontal axis*: Annotated entities (i.e., related terms) of Supply Chain encountered in the survey; *Vertical axis*: Percentage of ontologies studied in this survay (Orange: 100%; Blue: Frequency of individual annotated entities in Supply Chain ontologies).

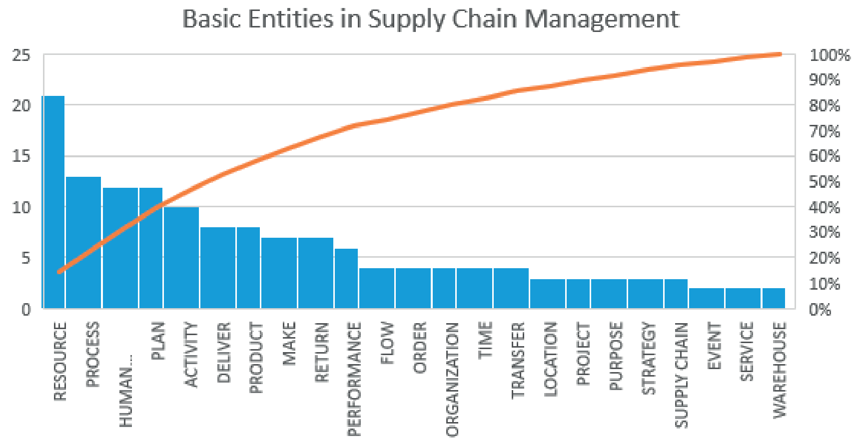

Figure 2. Pareto chart depicting the distribution of listed entities in descending order of frequency of occurrence in Supply Chain Management ontologies; *Horizontal axis*: Annotated entities (i.e., related terms) of Supply Chain encountered in the survey; *Left vertical axis*: Number of ontologies studied in this survey; *Right vertical axis*: Percentage of ontologies studied in this survay.

Furthermore, the figures (Figures 1-2) show that while some terms seem to be well represented, such as "Resource", others like "Warehousing" strongly lack representation in ontologies. As a result, underrepresented terms need further examination.

Thus, the creation of a new ontology that will try to solve as many problems as possible is not only necessary but also imperative, especially nowadays when technical systems offer unlimited possibilities. Therefore, the future goal of the authors is to take advantage of the new data in the field of ontology technology and create from scratch a new ontology of Supply Chain that will take into account the conclusions drawn from the present literature review and will aim at the integration of all Supply Chain systems.

References

Achatbi, I., Amechnoue, K., & Aoulad Allouch, S. (2018). An Ontology Based Approach to Organize Supplier and Transportation Provider Selection Negotiation in Multi-agent System Model. In M. Ezziyyani, M. Bahaj & F. Khoukhi (eds.), *Advanced Information Technology, Services and Systems*. AIT2S 2017. Lecture Notes in Networks and Systems, vol 25. Cham: Springer. https://doi.org/10.1007/978-3-319-69137-4_13

Anand, N., Yang, M., Van Duin, J.H.R., & Tavasszy, L. (2012). Genclon: An ontology for city logistics. *Expert Syst. Appl.*, *39*(15), 11944–11960. https://doi.org/10.1016/j.eswa.2012.03.068

Anand, N., Duin, J.H.R.V., & Tavasszy, L. (2016). Framework for Modelling Multi-stakeholder City Logistics Domain Using the Agent based Modelling Approach. *Transportation Research Procedia*, *16*, 4–15. https://doi.org/10.1016/j.trpro.2016.11.002

Blaj, A., Lambert, A., Lambert, C., Mulder, H., & Sauv, D. (2020). *ONE Record: One step closer to digital cargo with ontologies and linked data.* In the 19th International Semantic Web Conference on Demos and Industry Tracks: From Novel Ideas to Industrial Practice, ISWC-Posters 2020 (Vol. 2721, 2020, pp. 384-385); Virtual, Online; 1-6 November 2020.

Bruno, G., Antonelli, D., & Villa, A. (2015). A reference ontology to support product lifecycle management. *Procedia CIRP 2015*, 33, 41–46. https://doi.org/10.1016/j.procir.2015.06.009

Cao, M., Luo, X., Luo, X., & Dai, X. (2015). Automated negotiation for e-commerce decision making: A goal deliberated agent architecture for multi-strategy selection. *Decision Support Systems*, *73* (May 2015), 1–14. https://doi.org/10.1016/j.dss.2015.02.012

Chandra, C., & Tumanyan, A. (2007). Organization and problem ontology for supply chain information support system. *Data & Knowledge Engineering*, *61*(2), 263–280. https://doi.org/10.1016/j.datak.2006.06.005

Chaudhuri, A., Boer, H., Taran, Y. (2018). Supply chain integration, risk management and manufacturing flexibility. *International Journal of Operations & Production Management*, *38*(3), January 2018. https://doi.org/10.1108/IJOPM-08-2015-0508

Christopher, M. (1992). *Logistics and Supply Chain Management*. London: Pearson Education.

CLM (1998). *The Mission Section* (on line). Council of Logistics Management. http://www.clm1.org/mission.html

Daniele, L.M., & Pires, L.F. (2013). An ontological approach to logistics. Enterprise Interoperability, Research and Applications in the Service-oriented Ecosystem. In *IWEI'13 Proceedings*, Enschede, the Netherlands (May 2013). In book: Enterprise Interoperability, ISTE Ltd., 2014 (pp. 199-213). Surrey: John Wiley & Sons, Inc. https://doi.org/10.1002/9781118846995.ch21

Dewey, A., & Drahota, A. (2016). Introduction to systematic reviews: online learning module. Cochrane Training. https://training.cochrane.org/interactivelearning/module-1-introduction-conducting-systematic-reviews

Dorofeev, A., Altukhova, N., Filippova, N., Pashkova, T., & Ponomarev, M. (2020). Development of Transportation Management System with the Use of Ontological and Architectural Approaches to Ensure Trucking Reliability. *Sustainability*, *12*(20), 8504. https://doi.org/10.3390/su12208504

Durach, C.F., Kembro, J., & Wieland, A. (2017). A New Paradigm for Systematic Literature Reviews in Supply Chain Management. *Journal of Supply Chain Management*, *53*(4), 67–85. https://doi.org/10.1111%2Fjscm.12145

Engel, T., Bhat, M., Vasudhara, V., Goswami, S., & Krcmar, H. (2014). An Ontology-based Platform to Collaboratively Manage Supply Chains. In *25th Annual Conference of the Production and Operations Management Society (POMS)*, pp. 1–10. https://www.pomsmeetings.org/confpapers/051/051-0705.pdf

Fadel, F.G., Fox, M.S., & Gruninger, M. (1994). A generic enterprise resource ontology. In *Proceedings of the Third IEEE Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises*, West Virginia (WET ICE'94), April, 1994, pp. 117–128. https://doi.org/10.1109/ENABL.1994.330496

Fayez, F., Rabelo, L., & Mollaghasemi, M. (2005). Ontologies for Supply Chain Simulation Modeling. In M.E. Kuhl, N.M. Steiger, F.B. Armstrong & J.A. Joines (eds.), *2005 Winter Simulation Conference* (pp. 2364–2370). https://informs-sim.org/wsc05papers/296.pdf

Fox, M.S., Barbuceanu, M., & Gruninger, M. (1996). An organization ontology for enterprise modelling: preliminary concepts for linking structure and behaviour. *Computers in Industry*, *29*(1-2), 123–134. https://doi.org/10.1016/0166-3615(95)00079-8

Fox, M.S., & Gruninger, M. (1998). Enterprise modeling. *AI Magazine*, Fall 1998, 109–121.

Fox, M.S., Barbuceanu, M., Gruninger, M., & Lin, J. (1998). An organization ontology for enterprise modelling. In M. Prietula, K. Carley, L. Gasser (Eds.), *Simulating Organizations: Computational Models of Institutions and Groups* (pp. 131–152), AAAI/MIT Press, Menlo Park, 1998.

Foxvog, D., & Bussler, C. (2005). Ontologizing EDI: First Steps and Initial Experience. In *IEEE International Workshop on Data Engineering Issues in E-Commerce* (DEEC 2005), pp. 49-58. IEEE Computer Society, Los Alamitos, 2005. https://doi.org/10.1109/DEEC.2005.13

Geerts, G.L., & O'Leary, D.E. (2014). A supply chain of things: The EAGLET ontology for highly visible supply chains. *Decision Support Systems*, *63*(2014), 3–22. https://doi.org/10.1016/j.dss.2013.09.007

Glöckner, M., & Ludwig, A. (2016). LoSe ODP - An Ontology Design Pattern for Logistics Services. In *Workshop on Ontology and Semantic Web Patterns (7th edition)*, Pascal Hitzler, Karl Hammer, Monika Solanki, Agnieszka Lawrynowicz, Andrea Nuzzolese, and Adila Krisnadhi (Eds.). http://ontologydesignpatterns.org/wiki/images/f/fb/WOP2016_paper_14.pdf

Glöckner, M., & Ludwig, A. (2017). Ontological structuring of logistics services. In *Proceedings - 2017 IEEE/WIC/ACM International Conference on Web Intelligence*, WI 2017 (pp. 146-153). https://doi.org/10.1145/3106426.3106538

Gonnet, S., Vegetti, M., Leone, H., & Henning, G. (2006). SCOntology: A formal approach toward a unified and integrated view of the supply chain (Book Chapter). In *Adaptive Technologies and Business Integration: Social, Managerial and Organizational Dimensions* (pp. 137-158). https://doi.org/10.4018/978-1-59904-048-6.ch007

Grant, M.J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal*, *26*(2), 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Grubic, T., & Fan, S. (2010). Supply chain ontology: Review, analysis and synthesis. *Computers in Industry*, *61*(8), 776-786. https://doi.org/10.1016/j.compind.2010.05.006

Ha, J., Wei, Y., & Jin, Y. (2008). Logistics decision-making support system based on ontology process. *Int. Symp. Comput. Intell. Des.*, 2008, 309–312. https://doi.org/10.1109/ISCID.2008.128

Haller, A., Gontarczyk, J., & Kotinurm, P. (2008). Towards a complete SCM ontology: the case of ontologising RosettaNet. In *Proceedings of the 2008 ACM Symposium on Applied Computing*, SAC '08Fortaleza (pp. 1467-1473), Ceara, Brazil, March 16 - 20, 2008. https://doi.org/10.1145/1363686.1364029

Han, J., Miller, J.A., & Silver, G.A. (2011). Sopt: Ontology for simulation optimization for scientific experiments. In *Proceedings of the Winter Simulation Conference*, WSC '11 (pp. 2914–2925), Winter Simulation Conference.

Harland, C.M., Lamming, R.C., Zheng, J., & Johnsen, T.E. (2001). A Taxonomy of Supply Networks. *J. of Supply Chain Management*, Fall, 21-27. https://doi.org/10.1111/j.1745-493X.2001.tb00109.x

Haugen, R., & McCarthy, W.E. (2000). REA, a semantic model for Internet supply chain collaboration. In *OOPSALA 2000 Business Objects and Component Design and Implementation Workshop VI: Enterprise Application Integration 2000*. http://www.jeffsutherland.org/oopsla2000/mccarthy/mccarthy.htm

Hellenic Logistics Society - Thessaloniki Branch (2005). What is Logistics? Available at: http://www.logistics.org.gr (in Greek).

Hendi, H., Ahmad, A., Bouneffa, M., & Fonlupt, C. (2014). Logistics Optimization Using Ontologies. In *Proceedings of ICCSA 2014*, Jun 2014, Le Havre, France. ffhal-01651950ff.

Hepp, M. (2008). Good Relations: An Ontology for Describing Products and Services Offers on the Web. In *EKAW, 2008*, pp. 332–347. https://doi.org/10.1007/978-3-540-87696-0_29

Hoxha, J., Scheuerman, A., & Bloehdorn, S. (2010). An approach to formal and semantic representation of logistics services. In K. Schill, B. Scholz-Reiter & L. Frommberger (eds.), *Proceedings of the Workshop on Artificial Intelligence and Logistics (AILog) at the 19th European Conference on Artificial Intelligence (ECAI 2010)*, pp. 73–78, Lisbon, Portugal, published online.

Huang, G.Q., Lau, J.S.K., & Mak., K.L. (2003). The Impacts of Sharing Production Information on Supply Chain Dynamics: a review of the literature. *International Journal of Production Research*, *41*(7), 1483-1517. https://doi.org/10.1080/0020754031000069625

Huang, S.H., Sheoran, S.K., & Keskar, H. (2005). Computer-assisted supply chain configuration based on supply chain operations reference (SCOR) model. *Computers & Industrial Engineering*, 48, 377-394. https://doi.org/10.1016/j.cie.2005.01.001

Jiao, J.X., You, X., & Kumar, A. (2006). An agent-based framework for collaborative negotiation in the global manufacturing supply chain network. *Robotics and Computer-Integrated Manufacturing*, *22*(3), 239-255. https://doi.org/10.1016/j.rcim.2005.04.003

Kim, H.M., Fox, M.S., & Gruninger, M. (1999). An ontology for quality management-enabling quality problem identification and tracing. *BT Technology Journal*, *17*(4), 131–140. https://doi.org/10.1023/A:1009611528866

Knoll, D., Waldmann, J., & Reinhart, G. (2019). Developing an internal logistics ontology for process mining. *Science Direct, Procedia CIRP*, 79, 427-432. https://doi.org/10.1016/j.procir.2019.02.116

Koç, H., Lantow, B., & Sandkuhl, K. (2014). *Ontology Development for Intelligent Information Logistics in Transportation*. In *Proceedings of the 2nd International Workshop on Ontologies and Information Systems co-located with 13th International Conference on Perspectives in Business Informatics Research*, WOIS@BIR 2014, CEUR-WS, 2014 (pp. 2-17). Lund, Sweden, September 22nd, 2014. Retrieved January 2021 from: http://ceur-ws.org/Vol-1230/paper-01.pdf

Kumar, H, & Park, P. (2010). Know-ont: a knowledge ontology for an enterprise in an industrial domain. *International Journal of Database Theory and Application*, *3*(1), 23-32.

Lambert, D. (2004).The Eight Essential Supply Chain Management Processes. *Supply Chain Management Review*, 8(6), 18-26, January 2004.

Lambert, D.M, Emmelhainz, M.A, & Gardner, J.T. (1999). Building successful logistics partnerships. *Journal of Business Logistics*, *20*(1), 165–181.

Larson, P., & Halldorsson, A. (2004). Logistics versus supply chain management: An international survey. *International Journal of Logistics Research and Applications*, *7*(1), 17–31. https://doi.org/10.1080/13675560310001619240

Lee, T., Lee, I.H., Lee, S., Lee, S.G., Kim, D., & Chun J. et al. (2006). Building an operational product ontology system. *Electronic Commerce Research and Application*, *5*(1), 16–28. https://doi.org/10.1016/j.elerap.2005.08.005

Lemaignan, S., Siadat, A., Dantan, J.-Y., & Semenenko, A. (2006). *MASON: A proposal for an ontology of manufacturing domain*. In IEEE Work-shop on Distributed Intelligent Systems (DIS), pp. 195-200. Retrieved from: https://academia.skadge.org/publis/Lemaignan2006.pdf

Leukel, J., Hepp, M., Schmitz, V., & Tribowski, C. (2006). Ontologizing B2B Message Specifications: Experiences from Adopting the PLIB Ontology for Commercial Product Data. In *IEEE International Conference on e-Business Engineering (ICEBE 2006)*, pp. 146-153. IEEE Computer Society, Los Alamitos, 2006. https://doi.org/10.1109/ICEBE.2006.76

Leukel, J., & Kirn, S. (2008). A supply chain management approach to logistics ontologies in information systems. In W. Abramowicz & D. Fensel (eds.), *Business Information Systems* (vol. 7 of Lecture Notes in Business Information Processing, pp. 95–105). Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-540-79396-0_9

Lin, J., Fox, M.S., & Bilgic, T. (1996). *A requirement ontology for engineering design*. In *Proceedings of the 3rd International Conference on Concurrent Engineering*, pp. 343–351.

Lin, H.K., Harding, J.A., & Shahbaz, M. (2004). Manufacturing system engineering ontology for semantic interoperability across extended project teams. *International Journal of Production Research*, *42*(24), 5099–5118. https://doi.org/10.1080/00207540412331281999

Lin, H. K, & Harding, J.A. (2007). A manufacturing system engineering ontology model on the semantic web for interenterprise collaboration. *Computers in Industry*, *58*(2007), 428-437. https://doi.org/10.1016/j.compind.2006.09.015

Lu, Y., Panetto, H., Ni, Y., & Gu, X. (2012). Ontology alignment for networked enterprise information system interoperability in supply chain environment. *International Journal of Computer Integrated Manufacturing*, *26*(1-2), 1-12. https://doi.org/10.1080/0951192X.2012.681917

Madni, A.M., Lin, W., & Madni, C.C. (2001). IDEONTM: an extensible ontology for designing, integrating and managing collaborative distributed enterprises. *Systems Engineering*, *4*(1), 35–48. https://doi.org/10.1002/1520-6858(2001)4:1<35::AID-SYS4>3.0.CO;2-F

Marbert, V.A., & Venkataramanan, M.A. (1998). Special Research Focus on Supply Chain Linkages: Challenges for Design and Management in the 21st Century. *Decision Sciences*, *29*(3), S. 537–551. https://doi.org/10.1111/j.1540-5915.1998.tb01353.x

Marra, M., Ho, W., & Edwards, J.S. (2012). Supply chain knowledge management: A literature review. *Expert Systems with Applications*, *39*(5), 6103–6110. https://doi.org/10.1016/j.eswa.2011.11.035

Memon, M.A., Letouzey, A., Karray, M.H., & Archimède, B. (2014). Collaborating Multiple 3PL Enterprises for Ontology-Based Interoperable Transportation Planning. In K. Mertins, F. Bénaben, R. Poler, J.P. Bourrières (eds.), *Enterprise Interoperability VI*. Proceedings of the I-ESA Conferences, vol 7. Cham: Springer. https://doi.org/10.1007/978-3-319-04948-9_27

Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D., & Zacharia, Z.G. (2001). Defining Supply Chain Management. *Journal of Business Logistics*, 22, 1–25. https://doi.org/10.1002/j.2158-1592.2001.tb00001.x

Merdan, M., Koppensteiner, G., Hegny, I., & Favre-Bulle, B. (2008). Application of an ontology in a transport domain. *Industrial Technology*, 2008, 1–6. https://doi.org/10.1109/ICIT.2008.4608572

Moussas, V.J.T., & Tsahalis, H.T. (2013). Design of an ontology for simulation workflow optimization. In the *5th International Conference on Experiments/Process/System Modeling/Simulation/Optimization*, 2013.

Muñoz, E., Capón, E., Laínez, J.M., Espuña, A., & Puigjaner, L. (2001). Ontological framework for the enterprise from a process perspective: Operational, tactical and strategic integration for improved decision-making. In *KEOD 2011 - Proceedings of the International Conference on Knowledge Engineering and Ontology Development*, pp. 538-546.

Muñoz, E., Capón-García, E., Hungerbühler, K., Espuña, A., & Puigjaner, L. (2013). Decision making support based on a process engineering ontology for waste treatment plant optimization. *Chemical Engineering Transactions*, *32*, 277–282. https://doi.org/10.3303/CET1332047

Negri, E., Perotti, S., Fumagalli, L., Marchet, G., & Garetti, M. (2017). Modelling internal logistics systems through ontologies. *Computers in Industry*, *88*, 19–34. https://doi.org/10.1016/j.compind.2017.03.004

Obitko, M., & Marík, V. (2002). Ontologies for Multi-Agent Systems in Manufacturing Domain. In *Proceedings of the 13th International Workshop on Database and Expert Systems Applications (DEXA 2002)*. IEEE Computer Society, Aix-en-Provence, France 2002, pp. 597-602. https://doi.org/10.1109/DEXA.2002.1045963

OECD (1996). First OECD Workshop on Individual Travel Behaviour Values, Welfare and Quality of Life' Final Report; OCDE/GD(96) 199 OECD. Paris: Organisation for Economic Co-operation and Development.

Ontoweb Ontology-Based Information (2002). IST Project IST-2000-29243: OntoWeb - Ontology-based Information Exchange for Knowledge Management and Electronic Commerce D21 Successful Scenarios for Ontology-based Applications v1.0, see: http://people.cs.ksu.edu/~abreed/CIS890/References/OntoWeb_Del_2-1.pdf

Papakitsos, C. (2021). *Optimization and Sustainability of Supply Chain: The Application of Reverse Supply Chain - Case Studies* (in Greek). Integrated Master Dissertation, Department of Mechanical Engineering, University of West Attica, Greece.

Pawlaszczyk, D., Dietrich, A.J., Timm, I.J., Otto, S., & Kirn, S. (2004). *Ontologies Supporting Cooperation in Mass Customization – A Pragmatic Approach*. In International Conference on Mass Customization and Personalization – Theory and Practice in Central Europe (2004). Retrieved from: https://www.tu-menau.de/fileadmin/media/wid/forschung/Publikationen/OnlinePublikationen/2004-Pawlaszczyk-OntologiesSupporting.pdf

Piper, R.J. (2013). *How to write a systematic literature review: a guide for medical students*. University of Edinburgh.

Pittway, L. (2008). Systematic literature reviews. In R. Thorpe & R. Holt (Eds.), "The SAGE dictionary of qualitative management research". SAGE Publications Ltd. https://doi.org/10.4135/9780857020109

Ponanan, K., Suto, H., & Watanabe, S. (2017). An approach for supporting system of international logistics based on ontological engineering. In *Proceedings of the 2017 International Conference on Biometrics and Kansei Engineering, ICBAKE 2017*, 8090641, pp. 49–54. https://doi.org/10.1109/ICBAKE.2017.8090641

Prajogo, D., & Olhager, J. (2012). Supply chain integration and performance: the effects of long-term relationships, information technology and sharing, and logistics integration. *International Journal of Production Economics*, *135*(1), 514–522. https://doi.org/10.1016/j.ijpe.2011.09.001

Roder, A., & Tibken, B. (2006). A methodology for modeling inter-company supply chains and for evaluating a method of integrated product and process documentation. *European Journal of Operational Research*, *169*, 1010–1029. https://doi.org/10.1016/j.ejor.2005.02.006

Sakka, O., Millet, P-A., & Botta-Genoulaz, V. (2010). *An Owl Based Ontology of Scor Model: A Prerequisite for Strategic Alignment*. In the *8th International Conference of Modeling and Simulation - MOSIM'10* - May 10-12, 2010 - Hammamet – Tunisia, "Evaluation and optimization of innovative production systems of goods and services". Available from: https://www.researchgate.net/publication/228749588_AN_OWL_BASED_ONTOLOGY_OF_SCOR_MODEL_A_PREREQUISITE_FOR_STRATEGIC_ALIGNMENT

Sakka, O., Millet, P-A., & Botta-Genoulaz, V. (2011). An ontological approach for strategic alignment: A supply chain operations reference case study. *International Journal of Computer Integrated Manufacturing*, *24*(11), 1022–1037. https://doi.org/10.1080/0951192X.2011.575798

Samuel, K.E., Goury, M.L., Gunasekaran, A., & Spalanzani, A. (2011). Knowledge management in supply chain: An empirical study from France. *The Journal of Strategic Information Systems*, *20*(3), 283-306. https://doi.org/10.1016/j.jsis.2010.11.001

Scheuermann, A., & Hoxha, J. (2012). Ontologies for intelligent provision of logistics services. In The *Seventh International Conference on Internet and Web Applications and Services (ICIW'12)*, pp. 106-111.

Scheuermann, A., & Leukel, J. (2014). Supply chain management ontology from an ontology engineering perspective. *Comput. Ind.*, *65*(2014), 913–923. https://doi.org/10.1016/j.compind.2014.02.009

Sivamani, S., Kwak, K., & Cho, Y. (2014). A study on intelligent user-centric logistics service model using ontology. *Journal of Applied Mathematics*, 2014, 162838. https://doi.org/10.1155/2014/162838

Strzelczak, S., Balda, P., Garetti, M., & Lobov, A. (2015). *Open Knowledge-driven Manufacturing & Logistics*. The eScop Approach, Warsaw University of Technology Publishing House, Warsaw.

Smirnov, A.V., & Chandra, Ch. (2000). Ontology-Based Knowledge Management for Cooperative Supply Chain Configuration. Retrieved from: https://www.aaai.org/Papers/Symposia/Spring/2000/SS-00-03/SS00-03-013.pdf

Stevens, G.C. (1989). Integrating the Supply Chain. *International Journal of Physical Distribution & Materials Management*, *19*, 3–8. Retrieved from: https://pdfs.semanticscholar.org/792f/f5a74aac0672b52805198942a6051fd0caf1.pdf

Soares, A.L., Azevedo, A.L., & De Sousa, J.P. (2000). Distributed planning and control systems for the virtual enterprise: organizational requirements and development lifecycle. *Journal of Intelligent Manufacturing*, *11*(3), 253–270. https://doi.org/10.1023/A:1008967209167

Tamma, V., Phelps, S., Dickinson, I., & Wooldridge, M. (2005). Ontologies for supporting negotiation in e-commerce. *Eng. Appl. Artif. Intell.*, *18*(2005), 223–236. https://doi.org/10.1016/j.engappai.2004.11.011

Tham, K.D., Fox, M.S., & Gruninger, M. (1994). A cost ontology for enterprise modelling. In *Proceedings of the Third IEEE Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises*, West Virginia, April, (1994), pp. 111–117. https://doi.org/10.1109/ENABL.1994.330502

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *14*(3), 207-222. https://doi.org/10.1111/1467-8551.00375

Ureten, S., & Ilter, H.K. (2006). Supply Chain Management Ontology: Towards an Ontology-Based SCM Model. In the *Conference Proceedings of the Fourth International Logistics and Supply Chain Management Congress*. Izmir Economy University, Izmir, Turkey, 2006, pp. 741-749. https://doi.org/10.13140/2.1.2319.6169

Uschold, M., King, M., Moralee, S., & Zorgios, Y. (1998). The Enterprise Ontology. *The Knowledge Engineering Review*, *13*(1), 31–89. https://doi.org/10.1017/S0269888998001088

Vikram, N.K., Whitman, L., & Malzahn, D. (2003). Ontology-based Product Tracking System. Department of Industrial and Manufacturing Engineering, Wichita State University, USA. http://hdl.handle.net/10057/5913

Weber, J., Stolipin, J., König, M., & Wenzel, S. (2019). Ontology for logistics requirements on a 4D BIM for semi-automatic storage space planning. In *Proceedings of the 36th International Symposium on Automation and Robotics in Construction, ISARC 2019*, pp. 560–567. https://doi.org/10.22260/ISARC2019/0075

Witherell, P., Krishnamurty, S., & Grosse, I.R. (2006). Ontologies for supporting engineering design optimization. *Journal of Computing and Information Science in Engineering*. https://doi.org/10.1115/DETC2006-99508

Xu, D., Wijesooriya, C., Wang, Y.-G., & Beydoun, G. (2011). Outbound logistics exception monitoring: A multi-perspective ontologies' approach with intelligent agents. *Expert Systems with Applications*, *38*(11), 13604–13611. https://doi.org/10.1016/j.eswa.2011.04.111

Ye, Y., Yang, D., Jiang, Z., & Tong, L. (2008). Ontology-based semantic models for supply chain management. *The International Journal of Advanced Manufacturing Technology*, *37*(11-12), 1250–1260. https://doi.org/10.1007/s00170-007-1052-6

Yiqing, L., Lu, L., & Chen, L. (2009). Decision-making for supplier selection based on ontology and rules. In the *2nd International Conference on Intelligent Computing Technology and Automation, ICICTA 2009* 4, 5288243, pp. 176–179. https://doi.org/10.1109/ICICTA.2009.759

Yu-Liang, C. (2010). Rule-based ontological knowledge base for monitoring partners across supply networks. *Expert Systems with Applications*, *37*(2), 1400–1407. https://doi.org/10.1016/j.eswa.2009.06.097

Zdravković, M., Panetto, H., & Trajanović, M. (2010). Towards an Approach for Formalizing the Supply Chain Operations. In the *6th International Conference on Semantic Systems*, September 2010 Article No.: 19, pp. 1–5, ACM ICP, 8th Jun, 2010, Graz, Austria. https://doi.org/10.1145/1839707.1839732

Zhang, L., Jiang, D., Ju, Y., Wang, Q., & Li, P. (2013). Managing emergency material distribution knowledge using ontology-based modeling for emergency distribution decision. *Advanced Materials Research*, 605-607, 2337–2340. https://doi.org/10.4028/www.scientific.net/AMR.605-607.2337