Big Data application for E-commerce's Logistics: A research assessment and conceptual model

Article *in* IFAC-PapersOnLine · January 2019

DOI: 10.1016/j.ifacol.2019.11.234

CITATIONS
12

READS
158

3 authors, including:

Carina F. Dorneles
Federal University of Santa Catarina
56 PUBLICATIONS **263** CITATIONS
SEE PROFILE

Enzo Morosini Frazzon
Federal University of Santa Catarina
156 PUBLICATIONS **1,348** CITATIONS
SEE PROFILE

Available online at www.sciencedirect.com

ScienceDirect

IFAC Papers Online CONFERENCE PAPER ARCHIVE

IFAC PapersOnLine 52-13 (2019) 838–843

Big Data application for E-commerce's Logistics: A research assessment and conceptual model

Paula A. Hurtado * **Carina Dorneles** ** **Enzo Frazzon** ***

* *Universidade Federal de Santa Catarina, Industrial and Systems Engineering Department ,Florianpolis, SC, 88.040-001 BRAZIL E-mail: paula.hurtado@grad.ufsc.com*

** *Universidade Federal de Santa Catarina, Informatic and Statistics Department - INE/CTC, Florianpolis, SC, 88.040-001 BRAZIL E-mail: carina.dorneles@ufsc.br*

*** *Universidade Federal de Santa Catarina, Industrial and Systems Engineering Department ,Florianpolis, SC, 88.040-001 BRAZIL, (Tel: + 55-48-3721-7076; e-mail: enzo.frazzon@ufsc.br*

Abstract: Electronic commerce is growing continuously as a consequence of the advantages that it provides for consumers and companies. As the volume growth, several operational logistics challenges appear, mainly related to providing proper service levels which meet consumer expectations. The exploration of consumer behavior data to perform predictive analysis stands out as an option for overcoming logistic difficulties. Thereof, this paper assesses the e-commerce distribution operation and propose a novel conceptual model embracing the anticipation of e-commerce's demand based on the data collected by digital marketing, to enable predictive planning for the distribution of products.

Keywords: Digital Marketing; Demand Forecasting; Electronic Commerce; E-fulfillment.

1. INTRODUCTION

The increase of Internet availability through computers and mobile devices has levered the growth of the e-commerce market worldwide. In this scenario the consumer has access to a wide variety of products from several vendors all the time. These characteristics in the offer make the market very competitive by equalizing prices, in some cases trespassing the geographic barriers, providing advantages for the consumer (Allen and Fjermestad, 2001). However, the evolution of this activity is not beneficial only for consumers, but also for the industry. This type of trading can be operated with much less infrastructure and labor force than traditional trade, representing a business opportunity with a more efficient cost management (Galinari et al., 2015).

On the other hand, with increased demand, large challenges are also discovered, such the efficiency of the delivery operation which might be compromised, affecting the level of service and customer satisfaction. Due to this relation among freight conditions and customer satisfaction, is possible to inferred that logistic management has an impact in the customer decision making regarding the buyer journey (Ramanathan, 2010; Pyke et al., 2001). Than so, in order to maintain the growth of e-commerce it is necessary to study the possibilities of improvement in the logistic strategy. In turn, the exploitation of data on behaviour and the profile of consumers can be a valuable tool in this endeavor. (Mentzer et al., 2008). According to Leeflang et al. (2014), marketing is an area of knowledge that is closer to the consumer, where in fact the new paradigms in the digital sphere are revolutionizing the results and predictability of sales. Consequently, these data could be used for the management of supply chains so that they can more effectively meet the needs of the market. In fact in Zhao and Wang (2017) raw data from consumer behaviour online is processed with a convolutional neural network (CNN) to learn automatically features and predict sales. The results obtained with this approach were superior compared to auto regressive integrated moving average (ARIMA), feature extraction with gradient booster regression tree and Deep neural network (DNN).

Those e-fulfillment challenges have being documented by several authors in outstanding works such as Agatz et al. (2008) that focused in the multi-channel distribution and Pyke et al. (2001) that specifically addressed those topics in the furniture industry context. The contribution of this paper can be distiguished of previous works because (i) it brings a multidisciplinary perspective to the problem, (ii) presents a systematic research assessment, and (iii) it is not only descriptive but set the concepts for an innovative solution.

The following section will introduce fundamental concepts from the Knowledge areas related to the research problem. Then, in the sequence a research assessment for the e-commerce distribution operation is described, allowing to identify opportunities that lead to service level optimization. After that, due to aim to forecast e-commerce's demand and consequently create an adaptive planning for

10.1016/j.ifacol.2019.11.234

the distribution of products based on the data collected by digital marketing the conceptual model is presented. Finally an outline with the main research opportunities is given.

2. FUNDAMENTAL CONCEPTS

This research is located in the intersection of different knowledge areas. In essence it uses the integration between logistics and marketing, in order to create a Big data application to improve efficiency for the e-commerce industry.

2.1 E-commerce

The e-commerce definitions are varied, these are usually associated with the electronic nature of the channel through which the information of the purchase transaction is transmitted (Meng, 2009). The evolution of this type of commerce has happened in a gradual way, initially in the 1970's the only business relations that existed were among companies (B2B), later in the 1990's the first transactions from companies to Consumers (B2C) took place (Galinari et al., 2015).Then, The most recent type is where consumers do business directly with other consumers in the virtual realm (C2C).

Flexibility and ease are advantages that e-commerce offers to the consumer (Delfmann et al., 2002). In this way, the consumer no longer needs to visit different physical stores to find the products he wants to buy (Allen and Fjermestad, 2001).

2.2 Marketing

Multiple activities are performed within Marketing such as: Assessment of market opportunity; Assessment of perceived value by the customer; Sales projection; Product and service Relationship management; Communication with customers; Channel strategy and pricing. Nowadays the Internet provides a cybernetic space where organizations can maintain closer relationships with consumers than they have ever had at any other time in history (Allen and Fjermestad, 2001).

In that context, a fundamental concept that is gaining prominence since 2009, in this search for efficient actions of relationship is inbound marketing, this concept arose when the book "Inbound Marketing: Be found using Google, social media and blogs" by Halligan and Shah, whose principle is to make consumers those who go to companies and not on the contrary, the way to do so becomes a reality is to build a relationship where actions are executed by understanding the profile and interest of each consumer, respecting their moment in the buying journey (Holliman and Rowley, 2014). This is a path to change from the push strategy to the pull strategy, and its impact extends throughout the supply chain.

2.3 Logistics

The concept of logistics is evolving since its inception in World War II, where the concept was born to group the operations performed by the teams who were responsible for providing the necessary resources in the right place and time for the troops. Over time, this concept was taken to the organizational environment to reference the storage and transport operations. In this beginning the operations were performed in a reactive way and the delivery of value to the consumer was not recognized. Today are attributed to logistics four types of values: place, time, quality and information. Logistics concept is wide and not only comprehends the physical processes, but the services and associated information as well (Novaes, 2001; Agatz et al., 2008).

Thus, Logistics concept is comprehensive and involves multiple agents and processes that happen from the collect of the raw materials for production, as well as the ones that are performed to take the finished products to the hands of the consumer. This second one receives the name of distribution Logistics. In particular to refer the e-commerce the distribution processes the e-fulfillment concept was born, making the integration of the digital and the physical aspects through the distribution processes: warehouse management, sales, order management, delivery and after-sales service (Woudhuysen, 2001; Agatz et al., 2008; Pyke et al., 2001). According to some authors it might include the purchasing process when the operation is purely retail, but never the manufacturing.

2.4 Big Data Applications

With the popularity of the term Big data (BD) many definitions have been presented, they all have in common two points: storage and data Analysis. BD strictly refers to large volumes of data, but is often used to indicate data from different sources. With the large volume of data it is possible to obtain a lot of information, the main challenge is to ask the correct questions, to achieve proper data processing and to obtain reliable information. The applications of the concept of BD concept are very varied, for example Waller and Fawcett (2013) and Isasi et al. (2015) presented possible applications in the supply chain context. BD applications could provide the necessary information to make predictions with greater accuracy, allowing to respond to market demands more efficiently, reducing some uncertainties and thus reducing costs.

3. ASSESSMENT OF RESEARCH WORK IN THE E-COMMERCE DISTRIBUTION OPERATION

This section focus specifically in the e-commerce distribution operation, it presents a research assessment which is divided into six categories: E-commerce traffic sources; E-commerce Buyer Journey; Manufacturing; Line-Haul shipment; Last Mile delivery; Synchronized system. Each one of those categories contains multiple challenges an opportunities for research, three of those problems where listed and associated with a group of keywords to lead a consult in the Springer Database, the results for each problem are represented in figure 1.

3.1 E-commerce traffic sources

Companies are frequently looking for more efficient ways to communicate with their customers, those choices will change according to the industry because the channels performance will be different according to the context.

Despite that, the concept and the studies regarding digital sources are relatively new. For instance, the first work related to the topic of social media in Springer search took place in 2004 (Cheung, 2004).

3.2 E-commerce Buyer Journey

After the first contact with the company, it is possible to help the visitor to found the right product with recommendation tools based on similarity or buyer profile (Ogawa et al., 2008). But, beyond the product value proposition the company needs to offer a good experience, at that point reliability and Data Privacy are mandatory in the e-commerce environment. That might be a reason for the fact that the Data Privacy topic brought most of the results in this category, this reflects a huge concern due to internet penetration in the day-to-day life. From a technical point of view, multiple studies are in progress to understand the system requirements to enable a safe navigation for users while shopping in the internet (Cheung and Chanson, 2001).

3.3 Manufacturing

The manufacturing scheduling its a complex problem that combines multiple variables to produce an specific result allocating resources during a certain period of time. To solve that problem different approaches are proposed in the literature: data-driven (Kück et al., 2016); protocol based in the multi-agent paradigm (Kaihara and Fujii, 2005), among others. Also, in Varela et al. (2005) is presented a complete knowledge base for the manufacturing scheduling problem.

Beyond manufacturing scheduling, other concepts that are gaining relevance with the industry 4.0 applications are the smart manufacturing maintenance management and the fog computing. Rødseth et al. (2017) introduces an integrated planning for production and maintenance. Indeed, is for that kind of local processing need that the fog computing exists, allowing to process that data at the edge of the network without uploading unnecessary information to the cloud, in this field researches like the approaches to enable the exploration of those resources or the development of Fog orchestrator are being performed (Skarlat et al., 2017; Velasquez et al., 2018).

3.4 Line-Haul shipment

It is not usual to find information on the line-haul specifically for e-commerce, this also occurred with the manufacturing topics. But the available material is extensive, for instance the most popular topic in this category was related to the inventory management, which among others brought a result from 1963: McGarrah (1963).

The line-Haul (also knows as long-Haul) is the practice of moving loads of products among long distances, one of the main challenges is to do so in a economically viable solution, which is related to the choice of the route, the vehicle and the driver. In Wolfinger et al. (2018) multiple modals are explored to found more cheaper ways to do those deliveries with the use of a matheuristic, while Drexl et al. (2013) studied the possibility of route vehicles and drivers simultaneously in the line-haul european context through simulation with no important achievements for cost saving.

3.5 Last Mile delivery

Last mile delivery refers to the last transport before a product arrives to the costumer after leaving a hub or distribution center, this strategy allows to earn efficiency in the distribution operation because the vehicles sizes can be compatibilized with the amount of the packages to be deliver. In Arnold et al. (2018) different methods - self-pick-up, cargo bikes and delivery points- for this kind of delivery are quantified and evaluated with the use of simulation.

3.6 Synchronized system

As shown in the previous paragraphs there are many opportunities for the data extraction and local optimization enabled by technology in each of the different categories of this assessment. In the literature is possible to find authors that exposed some of the relations among those categories, for example in Barnett and Alexander (2004) is illustrated how the relation of the customer density with the fulfillment decisions for e- grocers can impact business profits. On the other hand Prockl et al. (2017) discuss about the necessity for a collaborative work between the Information management and supply chain management disciplines, presenting multiple points for collaboration. But none paper in the Springer consult presented insights on an global optimization for e-fulfillment based on customer behaviour data like presented in this paper.

4. BIG DATA APPLICATION FOR E-COMMERCE'S LOGISTICS

In order to enhance the efficiency of the e-commerce distribution logistics, through the use of consumer behaviour data a conceptual model was conceived based on the fundamental concepts presented earlier, the research assessment and previous practical experience in technology companies. The main components, characteristics and conditions for the conceptual model will be explained in this section. This conceptualization will allow scientific methods to be applied in the future in order to find other solutions.

4.1 Problem Definition

In the e-commerce transaction there are two main streams: the informational and the physical (Figure 2).Usually those are independent and their planning and operation is sequential compromising the efficiency and the service level. In the possibility of integrate both through the use of consumer behaviour remains an important improvement opportunity.

Indeed, the information flow can be related with the the buyer journey stages. For example, once a visitor is attracted to the e-commerce's domain it is expected that he will take an specific action associated to his moment in the buyer journey. For instance if he is a new visitor

Category	Problem/Challenge	Keywords	Related documents Springer
Ecommerce Traffic Sources	How to optimize the investment in paid media?	e$commerce; paid media; optimization;	197
	How to extract and use data from social networks?	E$commerce ; social networks ; data mining	481
	How to integrate information from different sources to predict demand?	e$commerce ; data integration; demand forecasting	201
Ecommerce Buyer Journey	How to provide a reliable ecommerce experience?	e$commerce ; reliability ; customer experience	452
	How I recommend the best product to a potential customer?	e$commerce ; recommendation ; similarity	302
	How to deal with data privacy?	e$commerce ; data privacy ; security	981
Manufacturing	How many products should I produce and when?	Manufacturing; machines ; dynamic scheduling	1282
	Can fog computing optimize manufacturing?	fog computing ; manufacturing	70
	Which machines are going to need maintenance and when?	manufacturing; preventive ; maintenance; scheduling	183
Line-Haul Shipment	Which transport should I use?	Transport; optimization ; line-haul	74
	How the load should be organized?	transport; load sizing ;optimization; logistics	337
	How to optimize inventory management?	inventory management ; logistics	1442
Last Mile delivery	Where my customers are located?	location; Marketing Data; e$commerce	896
	How to do product replenishment?	last-mile product replenishment	40
	How to provide traceability?	e-commerce; traceability	120
Synchronized system	How integrate the e-commerce marketing, production and distribution planning?	e-commerce; marketing; logistics; integrated planning	275

Fig. 1. Research assessment

the first interest for the company is to make the de-anonymization of this user obtaining their personal data to associate information such as browsing or social media behaviour, frequently the information used for this is the email. With a systematic processing it is possible to understand the profile and the moment in the buyer journey of each individual. Therefore, those responsible for doing marketing in internet, can use the information of their consumers to generate value for them (Allen and Fjermestad, 2001).

In more details it is possible to identify if the user is in the beginning of the journey doing the discovery of his necessities; Or if he already has a problem recognized and is at a moment closer to the decision making, where he only needs a few arguments to close a transaction - In this step the recommendation algorithms can aid the user to discover more products related to their interests - ; A third option would be that the person is already in the closing phase, probably already has a purchase intention and he is only choosing among the options that are available under certain conditions such as a fast delivery. After closing the first transaction, the process does not end and the relationship strategy must be continued to strengthen customer loyalty and thus guarantee new deal in the future.

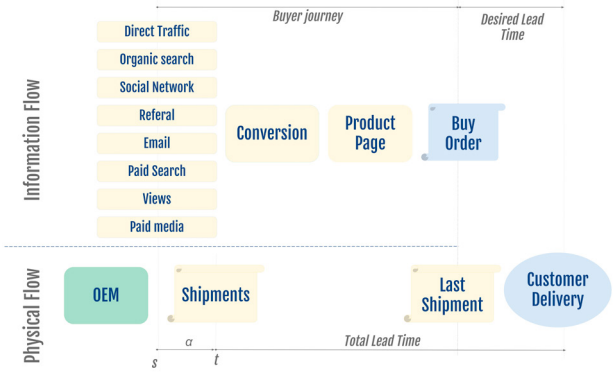

Fig. 2. Conceptual Model

Likewise, we have the physical flow of products where the possible channel combinations in the distribution chain are endless, as it depends on the particular needs of each industry and the company's financial strength to take initiatives to create and maintain this network. For example small e-commerce companies, might buy finalized products from vendors and use outsourced transportation services. However, there are also companies that control their entire distribution chain, from production or purchase to the physical store or distribution centers closest to the customers. The model proposed by this paper will describe the reality of these last companies. Similarly it is important to emphasize that the model will apply for operations with a considerable volume and a level of standardization medium or high, because when a product is tailor-made or highly customized it will be produced only after the receipt of the client's request (Made To Order) and in this case the proposal is to adopt a strategy similar to made to stock so that the product is available as close as possible to the consumer at the purchase moment.

However, it is well known that storage incurs not only in expenses due to the opportunity cost of the capital stored or in transit, but also the costs of the infrastructure for the operation. Ideally if the accuracy of this model was perfect the products would be produced or bought to go through the different shipping processes (Made To Ship), from the production center or from receiving the goods to the distribution center or physical store closest to the customer and on its arrival the customer purchase order would be in place creating a process very close to crossdocking, but that would include the processing of the purchase order: making the label, picking and re-packing.

4.2 Admitted conditions

For the purpose of idealizing the conceptual model of this work, some particular conditions on the electronic commerce distribution chain will be considered. The conceptual model will be described in detail in the subsequent section.

Condition 1: Regarding the business model, this model will consider companies that have decision-making power over their distribution chain and who work with low-or no-customized products, i.e. they can be manufactured before the arrival of the purchase order.

Condition 2: There will be an intermediate instance between line-haul shipment and last-mile delivery routes, this point should be as close to consumers as possible, so that the transport from that point to the customer delivery can be carried out in a short amount of time.

Condition 3: The time horizons remain undefined and there are differences between the cycles of the industries in which this model could be applied.

Condition 4: The detailed planning of each instance of the supply chain is already a complex problem but has been studied in the literature. For the purpose of formulating this model a simplification was made grouping all times and their variability in the Total Lead time (TLT), including transports and operations necessary from the starting point -production or purchase- to the arrival at the hands of the customer.

Condition 5: Similarly to condition 4, the capacity constraints of the different transport and storage methods along the distribution chain were not considered.

Condition 6: This model will plan on units per product, this will make sense for companies with a small or medium catalog. On the other side, companies with larger catalogues may jointly make use of product category and brand information.

4.3 Model Description

As placed in the problem Modeling section there are particularly two main streams in the problem under study: The information flow and the physical flow. All information from the information flow, including the different moments of the buyer journey from the first visit to the first purchase can be recorded in the virtual environment, allowing the calculation of the time of this stream. The main indicators of this flow are: visitors attracted by each channel, location of visitors, conversion rates, expected Return on Investment (ROI) of paid channels, average time of buyer journey, product price for each region.

The Desired Lead Time (DLT) is variable, purchases of furniture or customized products and appliances might have acceptance with a delivery period longer than one week, while smaller consumption products are expected to arrive at a shorter time. Then, the physical flow that encompasses all operations and intermediate transports as the possible passage through different distribution centers, physical stores, storage, picking, making of label, packaging and Dispatch is considered in a Single time called TLT. Despite this, as mentioned by condition 2 it is considered that there is an intermediate instance, close to the consumer where the products can receive the purchase order information, as the final delivery label.

Thus, this model proposes that the level of service is optimized by initiating intermediate shipments before the purchase order, at a time α from which the TLT coincide with the sum of the buyer journey and the LTD. This strategy is similar to the postponement movement proposal, which implies making the necessary customizations of the product in the last instance prior to contact with the consumer, and thereby avoiding intermediate inventories (Alvarado and Kotzab, 2001). In fact, Novaes (2001) reports that Benetton used the postponement technique to cope with the uncertainty in the colors of the products, making the most of the route with neutral colors, leaving to dye them very close to the moment of purchase.

Note that if the TLT is greater than the sum of the buyer journey with the LTD, the will assume a negative value and the production or purchase should be initiated even before the first visit of the consumer, returning to a sequence closer to the traditional model where they sell only the products that are already in stock. In this condition the model could help companies that make use of a third-party transport system, but have a physical store or distribution center close to the customer, allowing to make the demand projection for the decision to purchase or plan the production through the use of historical information on unpaid channel visits and investment decisions on paid channels. Finally the model will allow to calculate the number of products that must be delivered in each region r within the distribution schedule.

At the end, the mayor goal behind the execution of the proposed model would be to integrate the planning and control of the different processes and departments that contribute to the distribution operation, because in this integration rely the opportunity to reduce uncertainty and the cost related to them (Frazzon et al., 2015).

5. OUTLINE

The proposed model in this paper is ambitious and pretends to bring efficiency to the supply chain, future research will include the testing of scientific methods in simulated environments and real historic data sets, to later on be tested in a real operations.

The assessment presented confirms that even when the supply chain problems have being widely explored in the literature the problems regarding the application of new technologies remain unexplored, despite the growing tendency, which represents great opportunities for future research. The current state of e-commerce distribution operations generates huge amounts of data, but in the processing and interpretation of that data into valuable information relies a very interesting challenge. For example, the potential customer actions in some sources such as email clicks or previews can be easily quantified, but other sources such as social networks where unstructured formats can contain opinions or feelings that impact the brand perception of the audience are harder to be instrumented and measured. For some companies the structured information might be representative enough to infer information regarding the, while for others an holistic overview including unstructured information might be required to get significant results.

Likewise, that condition of heterogeneous data is present all the other stages of the distribution operation. Finally, in the evolution of the integrated use of that data remains a huge opportunity e-commerce logistics optimization.

REFERENCES

Agatz, N.A., Fleischmann, M., and Van Nunen, J.A. (2008). E-fulfillment and multi-channel distribution–a review. *European journal of operational research*, 187(2), 339–356.

Allen, E. and Fjermestad, J. (2001). E-commerce marketing strategies: an integrated framework and case analysis. *Logistics Information Management*, 14(1/2), 14–23.

Alvarado, U.Y. and Kotzab, H. (2001). Supply chain management: the integration of logistics in marketing. *Industrial marketing management*, 30(2), 183–198.

Arnold, F., Cardenas, I., Sörensen, K., and Dewulf, W. (2018). Simulation of b2c e-commerce distribution in antwerp using cargo bikes and delivery points. *European Transport Research Review*, 10(1), 2.

Barnett, M. and Alexander, P. (2004). The seven-step model for e-grocery fulfilment. In *Building the E-Service Society*, 375–394. Springer.

Cheung, T.W. and Chanson, S.T. (2001). A pki-based end-to-end secure infrastructure for mobile e-commerce. In *International Conference on Formal Techniques for Networked and Distributed Systems*, 421–441. Springer.

Cheung, W.K.W. (2004). e-transformation technologies: case studies and the road ahead-a value chain perspective. In *null*, 510–517. IEEE.

Delfmann, W., Albers, S., and Gehring, M. (2002). The impact of electronic commerce on logistics service providers. *International Journal of Physical Distribution & Logistics Management*, 32(3), 203–222.

Drexl, M., Rieck, J., Sigl, T., and Press, B. (2013). Simultaneous vehicle and crew routing and scheduling for partial-and full-load long-distance road transport. *Business Research*, 6(2), 242–264.

Frazzon, E.M., Albrecht, A., Hurtado, P.A., de Souza Silva, L., and Pannek, J. (2015). Hybrid modelling approach for the scheduling and control of integrated production and logistic processes along export supply chains. *IFAC-PapersOnLine*, 48(3), 1521–1526.

Galinari, R., Cervieri Júnior, O., Júnior, T., Rodrigues, J., and Rawet, E.L. (2015). Comércio eletrônico, tecnologias móveis e mídias sociais no brasil.

Halligan, B. and Shah, D. (2009). Inbound marketing: Get found using google. *Social Media and Blogs. Ed. Wiley.*

Holliman, G. and Rowley, J. (2014). Business to business digital content marketing: marketers perceptions of best practice. *Journal of research in interactive marketing*, 8(4), 269–293.

Isasi, N.K.G., Frazzon, E.M., and Uriona, M. (2015). Big data and business analytics in the supply chain: a review of the literature. *IEEE Latin America Transactions*, 13(10), 3382–3391.

Kaihara, T. and Fujii, S. (2005). Multi-agent based robust scheduling for agile manufacturing. In *Emerging Solutions for Future Manufacturing Systems*, 201–208. Springer.

Kück, M., Ehm, J., Freitag, M., Frazzon, E.M., and Pimentel, R. (2016). A data-driven simulation-based optimisation approach for adaptive scheduling and control of dynamic manufacturing systems. In *Advanced Materials Research*, volume 1140, 449–456. Trans Tech Publ.

Leeflang, P.S., Verhoef, P.C., Dahlström, P., and Freundt, T. (2014). Challenges and solutions for marketing in a digital era. *European management journal*, 32(1), 1–12.

McGarrah, R.E. (1963). *Production and Logistics Management: Text and Cases*. Wiley.

Meng, X. (2009). Developing model of e-commerce e-marketing. In *Proceedings. The 2009 International Symposium on Information Processing (ISIP 2009)*, 225. Citeseer.

Mentzer, J.T., Stank, T.P., and Esper, T.L. (2008). Supply chain management and its relationship to logistics, marketing, production, and operations management. *Journal of Business Logistics*, 29(1), 31–46.

Novaes, A.G. (2001). Logística e gerenciamento da cadeia de distribuição: Estratégia. *Operação e Avaliação. Rio de Janeiro: Editora Campus*.

Ogawa, Y., Suwa, H., Yamamoto, H., Okada, I., and Ohta, T. (2008). Development of recommender systems using user preference tendencies: An algorithm for diversifying recommendation. In *Towards Sustainable Society on Ubiquitous Networks*, 61–73. Springer.

Prockl, G., Bhakoo, V., and Wong, C. (2017). Supply chains and electronic markets-impulses for value co-creation across the disciplines. *Electronic Markets*, 27(2), 135–140.

Pyke, D.F., Johnson, M.E., and Desmond, P. (2001). E-fulfillment. *Supply Chain Management Review*, 27(5), 50–62.

Ramanathan, R. (2010). The moderating roles of risk and efficiency on the relationship between logistics performance and customer loyalty in e-commerce. *Transportation Research Part E: Logistics and Transportation Review*, 46(6), 950–962.

Rødseth, H., Schjølberg, P., and Marhaug, A. (2017). Deep digital maintenance. *Advances in Manufacturing*, 5(4), 299–310. doi:10.1007/s40436-017-0202-9. URL `https://doi.org/10.1007/s40436-017-0202-9`.

Skarlat, O., Nardelli, M., Schulte, S., Borkowski, M., and Leitner, P. (2017). Optimized iot service placement in the fog. *Service Oriented Computing and Applications*, 11(4), 427–443.

Varela, M.L.R., Aparício, J.N., and do Carmo Silva, S. (2005). A distributed knowledge base for manufacturing scheduling. In *Emerging Solutions for Future Manufacturing Systems*, 323–330. Springer.

Velasquez, K., Abreu, D.P., Assis, M.R., Senna, C., Aranha, D.F., Bittencourt, L.F., Laranjeiro, N., Curado, M., Vieira, M., Monteiro, E., et al. (2018). Fog orchestration for the internet of everything: state-of-the-art and research challenges. *Journal of Internet Services and Applications*, 9(1), 14.

Waller, M.A. and Fawcett, S.E. (2013). Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management. *Journal of Business Logistics*, 34(2), 77–84.

Wolfinger, D., Tricoire, F., and Doerner, K.F. (2018). A matheuristic for a multimodal long haul routing problem. *EURO Journal on Transportation and Logistics*, 1–37.

Woudhuysen, J. (2001). E-fulfilment: The opportunities for the future: Part one. *Interactive Marketing*, 2(3), 219–229.

Zhao, K. and Wang, C. (2017). Sales forecast in e-commerce using convolutional neural network. *arXiv preprint arXiv:1708.07946*.