11-2018

# A framework for investigating optimization of service parts performance with big data

Christopher A. Boone
*Texas Christian University*

Benjamin T. Hazen
*Air Force Institute of Technology*

Joseph B. Skipper
*Abraham Baldwin Agricultural College*

Robert E. Overstreet
*Iowa State University*, reo1@iastate.edu

# A framework for investigating optimization of service parts performance with big data


## Abstract

As national economies continue to evolve across the globe, businesses are increasing their capacity to not only generate new products and deliver them to customers, but also to increase levels of after-sales service. One major component of after-sale service involves service parts management. However, service parts businesses are typically seen as add-ons to existing business models, and are not well integrated with primary businesses. Consequently, many service parts operations are managed using ad-hoc practices that are often subordinated to primary businesses. Early research in this area has been instrumental in assisting organizations to begin optimizing some aspects of service parts management. However, performance goals for service parts management are often ill-defined. Further, because these service parts businesses are often subordinated to primary businesses within a firm, the use of newer big data applications to help manage these processes is almost completely absent. Herein, we develop a framework that seeks to define service parts performance goals for the purpose of outlining where scholars and practitioners can further examine where, how, and why big data applications can be employed to enhance service parts management performance.



## Keywords

Service parts, Big data, Supply chain management, Operations management


## Disciplines

Business Administration, Management, and Operations | Entrepreneurial and Small Business Operations | Management Information Systems | Operations and Supply Chain Management | Strategic Management Policy | Technology and Innovation


## Comments

This article is published as Boone, C.A., Hazen, B.T., Skipper, J.B., and Overstreet, R.E. (2018). A framework for investigating optimization of service parts performance with big data. Annals of Operations Research. 270(1–2), 65–74. DOI: 10.1007/s10479-016-2314-1.

Ann Oper Res (2018) 270:65–74
https://doi.org/10.1007/s10479-016-2314-1



# A framework for investigating optimization of service parts performance with big data

**Christopher A. Boone**[1] · **Benjamin T. Hazen**[2] · **Joseph B. Skipper**[3] · **Robert E. Overstreet**[4]

Published online: 15 September 2016


**Abstract** As national economies continue to evolve across the globe, businesses are increasing their capacity to not only generate new products and deliver them to customers, but also to increase levels of after-sales service. One major component of after-sale service involves service parts management. However, service parts businesses are typically seen as add-ons to existing business models, and are not well integrated with primary businesses. Consequently, many service parts operations are managed using ad-hoc practices that are often subordinated to primary businesses. Early research in this area has been instrumental in assisting organizations to begin optimizing some aspects of service parts management. However, performance goals for service parts management are often ill-defined. Further, because these service parts businesses are often subordinated to primary businesses within a firm, the use of newer big data applications to help manage these processes is almost completely absent. Herein, we develop a framework that seeks to define service parts performance goals for the purpose of outlining where scholars and practitioners can further examine where, how, and why big data applications can be employed to enhance service parts management performance.

**Keywords** Service parts · Big data · Supply chain management · Operations management

## 1 Introduction

Effective service parts management can create customer value and improve sustainability by extending product lifecycles (Wagner et al. 2012). Conversely, poor service parts management

✉ Benjamin T. Hazen
Benjamin.hazen@live.com

1 Neeley School of Business, Texas Christian University, Fort Worth, TX, USA

2 Department of Operational Sciences, Air Force Institute of Technology, Wright Patterson AFB, OH, USA

3 Stafford School of Business, Abraham Baldwin Agricultural College, Tifton, GA, USA

4 Department of Supply Chain and Information Systems, Iowa State University, Ames, IA, USA

can create operational inefficiencies, excess costs, and customer dissatisfaction (Harrington 2006). These realities have driven the annual investment in additional service parts inventory to more than $700 billion a year (Patton and Steele 2003) with another $100 million spent on systems to help manage them (Bacchetti and Saccani 2012) in hopes of ensuring the availability of assets critical to their manufacturing or customer service operations (Driessen et al. 2015).

Unfortunately, management of service parts is considered especially challenging (Boone et al. 2013) due to demand uncertainty, limited sourcing options, risk of obsolescence, inefficient ordering processes, poor inventory management, part proliferation, ageing systems and parts, and system configuration changes (Fortuin and Martin 1999; Kennedy et al. 2002; Patton and Steele 2003; Roda et al. 2014). Scholars have frequently sought to address these challenges as evidenced by the numerous publications focused on the topic across operations research, operations management, and supply chain management disciplines (Cohn and Barnhart 2006; Samouei et al. 2015). Unfortunately, the research is of limited use (Huiskonen 2001; Wagner et al. 2012) because proposed models can be too complex or costly to implement (Bacchetti and Saccani 2012). In addition, research on the role of big data in support of service parts management is completely absent. This is unfortunate, because in today's data driven environment, big data applications provide new capabilities that can help to better manage complex processes such as service parts management. Indeed, this is one area where collaboration amongst business disciplines, data scientists, and operations researchers could be most fruitful (Hazen et al. 2016).

It is this need to highlight potential areas where new big data analytics strategies can help to solve enduring problems that are a function of complex service parts management processes that motivates this research. Building on a series of semi-structured interviews with senior service parts managers, this research provides insight into the dynamics of using big data applications to support service parts management through the development of a performance framework depicting the complex environment faced by service parts managers. We also draw upon contingency theory to suggest future research that is more holistic and meaningful to managers. This research is not concerned with specific big data applications, but instead with defining the domain within which operations researchers can examine the role of big data for optimizing measures of service parts performance.

## 2 Research method

The research presented here was conducted as part of a larger investigation undertaken to improve our understanding of the critical decisions and challenges confronting service parts managers. A grounded theory approach was considered appropriate for this portion of the research effort given the focus on discovery (Flint et al. 2005) through practitioner interactions (Leonard and McAdam 2002). Interviews with senior service parts managers from a variety of industries were recorded, transcribed, and analyzed to identify emerging themes or categories (Gasson 2004). Thus, the resulting themes originate from the data, not pre-defined categories (Knapp 2005). Interviews continued until no new themes or categories emerged (i.e. saturation) (Corbin and Strauss 2008).

Also, in an effort to ensure the results were inclusive and generalizable, initial interviews were sought with managers representing a variety of industries including electronics, automotive, aviation production, medical equipment, and heavy equipment. This purposive sampling approach allowed for a more thorough investigation of the experiences and knowledge of

interest (Thomas et al. 2015) and the industries that have served as the basis for a number of prior service part focused research efforts including those by Fortuin and Martin (1999), Kutanoglu and Lohiya (2008), van den Berg et al. (2015), and Fawcett and Waller (2014). Interviews continued until no new concepts or themes emerged which Corbin and Strauss (2008) define as the point of saturation. A total of 17 interviews were completed.

## 3 Inductive model development and proposed research areas

One of the goals of the larger research effort mentioned previously, and focus of this paper, was to use insights gained from the interviews to develop a model or framework depicting the primary objectives and critical decisions faced by service parts managers. The resulting model highlights the complexity and interrelated nature of service parts management and also serves as the basis for a call for research aimed at assisting service parts managers to operate more efficiently and effectively in this environment. More specifically, research focused on the applications of big data and research grounded in contingency theory are recommended. In the sections that follow, the components of the model are discussed and examples of prior, related research are discussed.

## 4 Model description

When discussing the key challenges and decisions they faced, the managerial responses often varied depending on the performance goals of their approach to service parts management. The participants' responses revealed, in varying degrees, four distinct performance goals: maximize part availability, minimize cost of providing service parts, minimize the number of system disruptions, and maximize customer service and satisfaction. As Fig. 1 highlights, these goals are often in conflict.

Extant research describes these four performance goals to a great degree, as shown in Table 1. However, the highlighted research typically examines each in isolation, without addressing the effects on multiple outcomes identified in this research, or examining the interplay between performance goals. Indeed, a key finding of the current research is that a more holistic approach to examining performance outcomes is needed. In the sections that follow, each of the goals is discussed, related research is presented, and research opportunities are suggested.

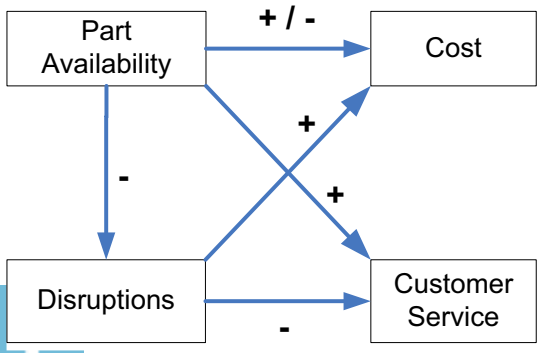


**Fig. 1** Performance objective model

**Table 1** Research regarding performance goals of service parts management

| Performance goal | Research example |
|---|---|
| Parts availability | Dekker et al. (1998), Schroter and Spengler (2004), Chang et al. (2005), Louit et al. (2011), Altay et al. (2012), Ghodrati et al. (2013), Kazemi Zanjani and Nourelfath (2014), Behfard et al. (2015), Jiang et al. (2015) |
| Disruptions | Pérez and Sánchez (2001), Skipper et al. (2010b), Li and Ryan (2011), Burns and Marx (2014), Sawik (2014, 2015) |
| Cost of providing service parts | Papazov and Tashev (1988), Evers (1999), Tibben-Lembke and Amato (2001), Thonemann et al. (2002), Wong et al. (2005), Topan and Bayindir (2012), Alptekinoğlu et al. (2013), Behfard et al. (2015), Diabat et al. (2015), Guajardo and Rönnqvist (2015) |
| Customer service and satisfaction | Gilmour et al. (1976), Cohen et al. (1989), Zeng (2003), Kranenburg and van Houtum (2008), Wikner and Tang (2008), Tysseland (2009), Skipper et al. (2010a), Makarova et al. (2011), Mondragon et al. (2011), Huscroft et al. (2013), Alvarez et al. (2015), Leyer and Moormann (2015) |

### 4.1 Parts availability

At the heart of this complex interaction lies parts availability, which is having service parts available and accessible upon demand by customers. Altay et al. (2012) demonstrated that inventory control policy, particularly for intermittent demand items like spare parts, has a significant role in parts availability. As demonstrated in Fig. 1, the goal of increased service part availability is to minimize system disruptions and increase customer service. Increased service part availability is expected to reduce the total number of inventory related disruptions by having parts available when required for service, thus providing improved customer service. However, an increase in availability typically requires an increase in on-hand inventory and thus an increase in overall cost of providing the service parts. The lack of available service parts may also increase costs by necessitating the use of expedited processes to satisfy customer demands. This delicate relationship between availability and cost is what prompted many of the participants to indicate that their primary goal is to seek a balance between the two. According to one participant, the true challenge is to understand the cost to make the part available as well as the cost associated with not having the part available.

A review of literature supports these findings. Extensive research has been conducted in this area to include studies on machine availability (Ghodrati et al. 2013), preventative maintenance (Jiang et al. 2015), and level of repair Chang et al. (2005) across industry segments such as Original Equipment Manufacturers (Behfard et al. 2015), third-party providers (Kazemi Zanjani and Nourelfath 2014), and electronics repair (Schroter and Spengler 2004). Despite research demonstrating the impact of service parts availability on overall cost (Louit et al. 2011) and customer service (Dekker et al. 1998), the data from the current research suggests a gap between extant research and managerial application in that most research examines only direct relationships between service parts management and one performance goal. Such research is instrumental in determining the relationships between these concepts, but does not take into account the holistic nature of service parts management performance. Indeed, more research is needed to holistically examine the performance goals of service parts management, as well as relationships proposed in Fig. 1.

### 4.2 Disruptions

A disruption, defined as the customer's lack of a needed service part whether due to internal issues (e.g., parts availability) or external issues (e.g., natural disaster), can prove very costly and can motivate customers to dispose of a product vice waiting to restore serviceability. Thus, many of the service parts managers described the need to focus on the essentiality and criticality of the parts they manage in an effort to reduce the number of internal disruptions of the systems they supported. This was especially important to those in the manufacturing, aviation, computer network, and utility industries. An increase in the number of disruptions in one of these industries can result in increased cost and lost opportunities (e.g. lost sales, cancellations, delays). Skipper et al. (2010b) point out the broad ranging impact of service disruptions. Ranging from automotive parts providers (Burns and Marx 2014; Pérez and Sánchez 2001) to machine parts (Li and Ryan 2011), a disruption in the availability of service parts may have a devastating impact on customer service (Sawik 2014, 2015).

A service parts manager from the utility industry estimated that the lack of a service part, which required a power unit to reduce power or shut down, could result in a loss of up to $1 million in revenue per day. A service parts manager tasked with supporting a large information network provider estimated that for every one hour the network was down, the companies utilizing that network combined for a loss of nearly $80,000 in revenue per hour. In turn, this makes the idea of servicing products to increase their lifecycle (vice purchasing new products or having new products on hand) too risky for some firms in these critical industries.

### 4.3 Cost of providing service parts

The participants indicated that controlling the costs associated with holding and managing inventory was an important goal of their service parts management efforts. There are many factors that influence the cost of providing service parts inventory. Ranging from warehousing and distribution center (Diabat et al. 2015; Thonemann et al. 2002; Topan and Bayindir 2012) to labor (Papazov and Tashev 1988) and forecasting (Tibben-Lembke and Amato 2001), cost research in spare parts is far reaching. Several research efforts also incorporate cost saving measures such as pooling (Evers 1999; Guajardo and Rönnqvist 2015; Wong et al. 2005) and postponement (Alptekinoğlu et al. 2013; Behfard et al. 2015).

Participants in the current research pointed to rising costs in warehousing as well as the need to reduce their firm's footprint as driving forces behind the need to reduce storage space requirements. Another participant pointed to the cost of labor as a key driver of the cost of providing service. Still another pointed to the increase in fuel costs and emissions as a critical factor that must be considered. Of course the primary means for reducing costs is to simply reduce the amount of on-hand inventory. However, many of the service parts managers warned that efforts to "lean" service parts inventory must be entered into cautiously. Unlike most manufacturing inventories, the lack of service parts inventory can mean the complete shutdown of an organization's operations.

### 4.4 Customer service and satisfaction

Underlying all of the aforementioned goals is a focus on customer service and satisfaction, defined herein as a customer's favorable experience following one or more interactions with a supplier (Klaus 2013). Whether through the reductions in cost, availability of parts, or minimization of disruptions, the primary goal of service parts management is customer satisfaction. A number of the participants highlighted this with comments like: "our focus is

always on the customer," "our primary goal is customer satisfaction," or "our sole objective is customer satisfaction." Indeed, service parts management processes must be established to meet the specific needs of each customer in each environment. This requires flexibility on the part of service parts managers, a delicate interplay between different goals, and continuous review of strategies and procedures.

The research involving the impact of spare parts availability on customer service is quite significant. In this area, research efforts, primarily models, cover a broad range of topics including stockage policies (Cohen et al. 1989; Leyer and Moormann 2015; Tysseland 2009), network management (Makarova et al. 2011; Skipper et al. 2010a; Zeng 2003), warranties (Wikner and Tang 2008), remanufacturing (Huscroft et al. 2013; Mondragon et al. 2011; Wikner and Tang 2008), and service differentiation (Alvarez et al. 2015; Gilmour et al. 1976; Kranenburg and van Houtum 2008). Although this research typically addresses each topic in a comprehensive manner, it rarely takes into account the delicate interplay between all facets of customer satisfaction and performance.

## 5 Future research opportunities

In addition to the research opportunities suggested for each objective depicted in the model, we also believe that scholars should explore the potential use of big data and big data related tools to improve service parts management and that contingency theory is an especially promising theory upon which to base the research. Contingency theory appears especially well suited for investigating the complexities of service parts management, but has thus far been rarely used in this literature stream. Contingency theory suggests organizational performance is maximized when processes and structures "fit" the environment (Lawrence et al. 1967), suggesting service parts managers can be most effective by opting for strategies or tools that best complement their specific circumstances (Bacchetti and Saccani 2012; Boone et al. 2013). Using a contingency theory approach, scholars could provide especially useful insights for managers by exploring the effectiveness of different big data strategies or techniques in varying contexts or environments.

Contingency theory implies that firms adapt to changes in their environment by modifying their approach to competition in order to maintain or enhance performance (Hoffer 1975). As a new dimension on which firms compete, big data implies a new approach to achieving marketplace differentiation and increased performance. The willingness and ability of organizations to deal with changes in their operating environment by employed such advancements has been documented as a cornerstone of firm strategy and performance (Hambrick 1983; Herbert and Deresky 1987; Porter 1980). Contingency theory provides a basic rationale for emphasis on flexibility-based strategies that big data provides, which represents a strategic response to emerging threats (Bolwijn and Kumpe 1990; Fawcett et al. 1996). Bracker (1980) argued that firms utilize resources as necessary to achieve specified objectives within a specific competitive environment and under specific conditions. This view can be most helpful in examining the utilization of service parts resources.

The application of big data strategy and strategic planning processes focus the organization's resources in a manner that enhances firm performance via a competitive driver, such as flexibility (Fawcett et al. 1996). The importance of big data strategy can be identified in two primary areas. The first is seen in the identification of the organization's core competencies and objectives (Hazen et al. 2014). Second, big data strategy guides the process by which firms' data resources are developed, organized, and allocated in order to achieve selected goals (Fawcett et al. 1996; Waller and Fawcett 2013).

Contingency theorists have argued that strategic planning linked to performance increases the understanding of the "situational" effects of planning on performance (Egelhoff 1984, 1985; Skipper et al. 2014). Wolf and Egelhoff (2002) go on to add that strategic planning fosters a consistent conceptualization of strategic planning characteristics and their relationships to different organizational and environmental characteristics. This emphasis on the strategic nature of service parts management can inform research seeking to examine the role that big data can play in optimizing measures of performance.

## 6 Concluding remarks

Those companies that manage service parts effectively can realize improved customer loyalty, measures of sustainability, and higher profits (Wagner et al. 2012), while poor management of service parts can have a detrimental impact on the entire supply chain (Zsidisin et al. 2004). Thus, service parts management is an increasingly valuable and important part of many organizations. Managers of service parts must maintain a delicate balance between cost and availability, and must pay careful attention to the potential cost of disruptions caused by a lack of service parts and constantly seek to improve customer service. Big data applications are proposed to help achieve these objectives.

Big data is expected to revolutionize modern supply chains (Waller and Fawcett 2013) and holds great potential for improving service parts management. Thus, investigations focused on the use of big date to improve service parts management are needed. The model developed answers the call by Bacchetti and Saccani (2012) for service parts management frameworks and provides a basis upon which researchers can build via theoretically grounded and practitioner oriented research.

## References

Altay, N., Litteral, L. A., & Rudisill, F. (2012). Effects of correlation on intermittent demand forecasting and stock control. *International Journal of Production Economics*, *135*(1), 275–283.

Alptekinoğlu, A., Banerjee, A., Paul, A., & Jain, N. (2013). Inventory pooling to deliver differentiated service. *Manufacturing & Service Operations Management*, *15*(1), 33–44.

Alvarez, E., Heijden, M., & Zijm, W. (2015). Service differentiation in spare parts supply through dedicated stocks. *Annals of Operations Research*, *231*(1), 283–303.

Bacchetti, A., & Saccani, N. (2012). Spare parts classification and demand forecasting for stock control: Investigating the gap between research and practice. *Omega*, *40*(6), 722–737.

Behfard, S., van der Heijden, M. C., Al Hanbali, A., & Zijm, W. H. M. (2015). Production, manufacturing and logistics: Last time buy and repair decisions for spare parts. *European Journal of Operational Research*, *244*, 498–510.

Bolwijn, P. T., & Kumpe, T. (1990). Manufacturing in the 1990s-productivity, flexibility and innovation. *Long Range Planning*, *23*(4), 44–48.

Boone, C. A., Craighead, C. W., Hanna, J. B., & Nair, A. (2013). Implementation of a system approach for enhanced supply chain continuity and resiliency: A longitudinal study. *Journal of Business Logistics*, *34*(3), 222–235.

Bracker, J. (1980). The historical development of the strategic management concept. *Academy of Management Review*, *5*(2), 219–224.

Burns, K. F., & Marx, T. G. (2014). Crisis Management planning among tier 2 automobile suppliers: Why suppliers fail to plan. *Journal of Contingencies & Crisis Management*, *22*(2), 108–112.

Chang, P.-L., Chou, Y.-C., & Huang, M.-G. (2005). A (r, r, Q) inventory model for spare parts involving equipment criticality. *International Journal Of Production Economics*, *97*(1), 66–74.

Cohen, M. A., Kleindorfer, P. R., & Lee, H. L. (1989). Near-optimal service constrained stocking policies for spare parts. *Operations Research*, *37*(1), 104.

Cohn, A. M., & Barnhart, C. (2006). Composite-variable modeling for service parts logistics. *Annals of Operations Research*, *144*(1), 17–32.
Corbin, J., & Strauss, A. (2008). *Basics of qualitative research 3e*. London: Sage.
Dekker, R., Kleijn, M. J., & De Rooij, P. (1998). A spare parts stocking policy based on equipment criticality. *International Journal Of Production Economics*, *56*, 69–77.
Diabat, A., Abdallah, T., & Henschel, A. (2015). A closed-loop location-inventory problem with spare parts consideration. *Computers & Operations Research*, *54*, 245–256.
Driessen, M., Arts, J., van Houtum, G.-J., Rustenburg, J. W., & Huisman, B. (2015). Maintenance spare parts planning and control: A framework for control and agenda for future research. *Production Planning & Control*, *20*, 407–426.
Egelhoff, W. G. (1984). Patterns of control in U.S., UK, and European multinational corporations. *Journal of International Business Studies*, *15*(2), 73–83.
Egelhoff, W. G. (1985). *Planning processes in multinational corporations: A contingency model*. Paper presented at the fourth annual strategic management society conference, Spain.
Evers, P. T. (1999). Filling Customer orders from multiple locations: A comparison of pooling methods. *Journal of Business Logistics*, *20*(1), 121–139.
Fawcett, S. E., Calantone, R. J., & Smith, S. (1996). An investigation of the impact of flexibility on global reach and firm performance. *Journal of Business Logistics*, *17*(2), 167–196.
Fawcett, S. E., & Waller, M. A. (2014). Supply chain game changers-mega, nano, and virtual trends-and forces that impede supply chain design (ie, building a winning team). *Journal of Business Logistics*, *35*(3), 157–164.
Flint, D. J., Larsson, E., Gammelgaard, B., & Mentzer, J. T. (2005). Logistics innovation: A customer value-oriented process. *Journal of Business Logistics*, *26*(1), 113–147.
Fortuin, L., & Martin, H. (1999). Control of service parts. *International Journal of Operations and Production Management*, *19*(9), 950–971.
Gasson, S. (2004). Rigor in grounded theory research: An interpretive perspective on generating theory from qualitative field studies. In M. E. Whitman & A. B. Woszczynski (Eds.), *The Handbook of Information Systems Research* (pp. 79–102). Hershey, PA: Idea Group Publishing.
Ghodrati, B., Ahmadi, A., & Galar, D. (2013). Spare parts estimation for machine availability improvement addressing its reliability and operating environment—Case study. *International Journal of Reliability, Quality & Safety Engineering*, *20*(3), 1–15.
Gilmour, P., Borg, G., Duffy, P. A., Johnston, N. D., Limbek, B. E., & Shaw, M. R. (1976). Customer service: Differentiating by market segment. *International Journal of Physical Distribution*, *7*(3), 141–148.
Guajardo, M., & Rönnqvist, M. (2015). Cost allocation in inventory pools of spare parts with service-differentiated demand classes. *International Journal of Production Research*, *53*(1), 220–237.
Hambrick, D. C. (1983). An empirical typology of mature industrial-product environments. *Academy of Management Journal*, *26*(2), 213–230.
Harrington, L. (2006). Getting service parts logistics up to speed. *Inbound Logistics*, (November 2006). Retrieved from http://www.inboundlogistics.com/cms/article/getting-service-parts-logistics-up-to-speed/.
Hazen, B. T., Boone, C. A., Ezell, J. D., & Jones-Farmer, L. A. (2014). Data quality for data science, predictive analytics, and big data in supply chain management: an introduction to the problem and suggestions for research and applications. *International Journal Of Production Economics*, *154*, 72–80.
Hazen, B. T., Skipper, J. B., Boone, C. A., & Hill, R. R. (2016). Back in business: Operations research in support of big data analytics for operations and supply chain management. *Annals of Operations Research*. doi:10.1007/s10479-016-2226-0.
Herbert, T. T., & Deresky, H. (1987). Generic strategies: An empirical investigation of typology validity and strategy content. *Strategic Management Journal*, *8*(2), 135–147.
Hoffer, C. W. (1975). Toward a contingency theory of business strategy. *Academy of Management Journal*, *18*(4), 784–810.
Huiskonen, J. (2001). Maintenance spare parts logistics: Special characteristics and strategic choices. *International Journal Of Production Economics*, *71*(1), 125–133.
Huscroft, J. R., Hazen, B. T., Hall, D. J., Skipper, J. B., & Hanna, J. B. (2013). Reverse logistics: Past research, current management issues, and future directions. *The International Journal of Logistics Management*, *24*(3), 304–327.
Jiang, Y., Chen, M., & Zhou, D. (2015). Technical paper: Joint optimization of preventive maintenance and inventory policies for multi-unit systems subject to deteriorating spare part inventory. *Journal of Manufacturing Systems*, *35*, 191–205.
Kazemi Zanjani, M., & Nourelfath, M. (2014). Integrated spare parts logistics and operations planning for maintenance service providers. *International Journal Of Production Economics*, *158*, 44–53.

Kennedy, W. J., Patterson, J. W., & Fredendall, L. D. (2002). An overview of recent literature on spare parts inventories. *International Journal Of Production Economics*, *76*, 201–215.
Klaus, P. (2013). The case of Amazon.com: Towards a conceptual framework of online customer service experience (OCSE) using the emerging consensus technique (ECT). *Journal of Services Marketing*, *27*(6), 443–457.
Knapp, K. J. (2005). *A model of management effectiveness in information security: From grounded theory to empirical test* (Doctor of Philosophy Dissertation). Auburn University, Auburn, AL.
Kranenburg, A. A., & van Houtum, G. J. (2008). Service Differentiation in spare parts inventory management. *Journal of the Operational Research Society*, *59*(7), 946–955.
Kutanoglu, E., & Lohiya, D. (2008). Integrated inventory and transportation mode selection: A service parts logistics system. *Transportation Research Part E: Logistics and Transportation Review*, *44*(5), 665–683.
Lawrence, P. R., Lorsch, J. W., & Garrison, J. S. (1967). *Organization and environment: Managing differentiation and integration: Division of research, graduate school of business administration*. Boston, MA: Harvard University.
Leonard, D., & McAdam, R. (2002). The strategic dynamics of total quality management: A grounded theory research study. *The Quality Management Journal*, *9*(1), 50–62.
Leyer, M., & Moormann, J. (2015). Comparing concepts for shop floor control of information-processing services in a job shop setting: A case from the financial services sector. *International Journal of Production Research*, *53*(4), 1168–1179.
Li, R., & Ryan, J. K. (2011). A Bayesian Inventory Model using real-time condition monitoring information. *Production & Operations Management*, *20*(5), 754–771.
Louit, D., Pascual, R., Banjevic, D., & Jardine, A. K. S. (2011). Optimization models for critical spare parts inventories—A reliability approach. *Journal of the Operational Research Society*, *62*(6), 992–1004.
Makarova, I., Khabibullin, R., Buyvol, P., & Belyaev, Ebmr. (2011). Concept of the dealer-service network management on the system approach basis. *Transport Problems: An International Scientific Journal*, *6*(4), 135–140.
Mondragon, A. E. C., Lalwani, C., & Mondragon, C. E. C. (2011). Measures for auditing performance and integration in closed-loop supply chains. *Supply Chain Management: An International Journal*, *16*(1), 43–56.
Papazov, K., & Tashev, A. (1988). A possibility of spare parts planning improvement in the production enterprises. *Engineering Costs & Production Economics*, *15*(1–4), 211–214.
Patton, J. D., & Steele, R. J. (2003). *Service Parts handbook*. Rego Park, NY: Solomon Press.
Pérez, M. P., & Sánchez, A. M. (2001). Supplier relations and flexibility in the Spanish automotive industry. *Supply Chain Management: An International Journal*, *6*(1), 29–38. doi:10.1108/13598540110381272.
Porter, M. (1980). *Competitive strategy*. New York: Free Press.
Roda, I., Macchi, M., Fumagalli, L., & Viveros, P. (2014). A review of multi-criteria classification of spare parts: From literature analysis to industrial evidences. *Journal of Manufacturing Technology Management*, *25*(4), 528–549.
Samouei, P., Kheirkhan, A. S., & Fattahi, P. (2015). A network approach modeling of multi-echelon spare-part inventory system with backorders and quantity discount. *Annals of Operations Research*, *226*(1), 551–563.
Sawik, T. (2014). On the robust decision-making in a supply chain under disruption risks. *International Journal of Production Research*, *52*(22), 6760–6781.
Sawik, T. (2015). On the fair optimization of cost and customer service level in a supply chain under disruption risks. *Omega*, *53*, 58–66.
Schroter, M., & Spengler, T. (2004). Designing control management systems for parts recovery and spare parts management in the final phase within closed-loop supply chains. *International Journal of Integrated Supply Management*, *1*(2), 158–179.
Skipper, J. B., Bell, J. E., Cunningham, W. A, I. I. I., & Mattioda, D. D. (2010a). Forward positioning and consolidation of strategic inventories. *Journal of Transportation Management*, *21*(1), 27.
Skipper, J. B., Hall, D. J., Hazen, B. T., & Hanna, J. B. (2014). Achieving flexibility via contingency planning activities in the supply chain. *International Journal of Information Systems and Supply Chain Management*, *7*(2), 1–21.
Skipper, J. B., Hanna, J. B., & Gibson, B. J. (2010b). Alabama power response to Katrina: Managing a severe service supply chain disruption. *Journal of the International Academy for Case Studies*, *16*(1), 21–31.
Thomas, S. P., Manrodt, K. B., & Eastman, J. K. (2015). The impact of relationship history on negotiation strategy expectations: A theoretical framework. *International Journal of Physical Distribution & Logistics Management*, *45*(8), 794–813.
Thonemann, U. W., Brown, A. O., & Hausman, W. H. (2002). Easy quantification of improved spare parts inventory policies. *Management Science*, *48*(9), 1213–1225.

Tibben-Lembke, R. S., & Amato, H. N. (2001). Replacement parts management: The value of information. *Journal of Business Logistics*, *22*(2), 149–164.
Topan, E., & Bayindir, Z. P. (2012). Multi-item two-echelon spare parts inventory control problem with batch ordering in the central warehouse under compound poisson demand. *Journal of the Operational Research Society*, *63*(8), 1143–1152.
Tysseland, B. E. (2009). Spare parts optimization process and results: Opus10 cases in the Norwegian defence. *International Journal of Physical Distribution & Logistics Management*, *39*(1), 8–27.
van den Berg, D., van der Heijden, M., & Schuur, P. (2015). Allocating service parts in two-echelon networks at a utility company. *International Journal Of Production Economics*. doi:10.1016/j.ijpe.2015.08.025.
Wagner, S. M., Jönke, R., & Eisingerich, A. B. (2012). A strategic framework for spare parts logistics. *California Management Review*, *54*(4), 69–92.
Waller, M. A., & 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.
Wikner, J., & Tang, O. (2008). A structural framework for closed-loop supply chains. *The International Journal of Logistics Management*, *19*(3), 344–366.
Wolf, J., & Egelhoff, W. G. (2002). A reexamination and extension of international strategy–structure theory. *Strategic Management Journal*, *23*(2), 181–189.
Wong, H., Cattrysse, D., & Van Oudheusden, D. (2005). Inventory pooling of repairable spare parts with non-zero lateral transshipment time qnd delayed lateral transshipments. *European Journal of Operational Research*, *165*(1), 207–218.
Zeng, A. Z. (2003). Global sourcing: Process and design for efficient management. *Supply Chain Management: An International Journal*, *8*(4), 367–379.
Zsidisin, G. A., Ellram, L. M., Carter, J. R., & Cavinato, J. L. (2004). An analysis of supply risk assessment techniques. *International Journal of Physical Distribution & Logistics Management*, *34*(5), 397–413.