



Received : January 12, 2019 Accepted : April 28, 2019


<http://dx.doi.org/10.26650/JTL.2018.04.01.03>

Research Article

Performance Measurement System for Automotive Spare Parts Supply Chain: A Categorization Approach

Zineb Achetoui | Laboratory of Engineering, Industrial Management and Innovation, Hassan First University, Faculty of Science and Technology, Settat, Morocco achetoui.zineb@gmail.com 

Charif Mabrouki | Laboratory of Engineering, Industrial Management and Innovation, Hassan First University, Faculty of Science and Technology, Settat, Morocco 

Ahmed Mousrij | Laboratory of Engineering, Industrial Management and Innovation, Hassan First University, Faculty of Science and Technology, Settat, Morocco 

Keywords: Performance, Supply chain, Spare parts, Automotive, Categorization	ABSTRACT This paper provides a categorization approach that encompasses the required categories and subcategories for the performance measurement of automotive spare parts supply chain, with a focus on independent distributor belonging to the independent channel. In fact, the particular characteristics of spare parts have led to the emergence of many scientific contributions related to inventory management and demand forecasting methods. However, little research has focused on the measurement of the spare parts supply chain performance despite its big importance. In this paper, we attempt to fill this gap in the literature, in particular for the automotive aftermarket, by proposing a framework that will lead to the measurement of the overall automotive spare parts supply chain performance.
--	--

Cite this article as

Achetoui, Z., Mabrouki, C., & Mousrij, A. (2019). Performance Measurement System for Automotive Spare Parts Supply Chain: A Categorization Approach. *Journal of Transportation and Logistics*, 4(1), 31-50. doi: 10.26650/JTL.2018.04.01.03



1. Introduction

The automotive aftermarket is a diversified sector that forms a part of the automotive industry. It encompasses manufacturing and distribution of spare parts as well as maintenance and repair in order to extend the life of vehicles sold to final customers.

In spite of being a source of substantial revenues, the automotive aftermarket is subject to changes due to technological evolution of the automotive industry, emerging spare parts markets and competitive pressure. These changes largely affect the manufacturers and distributors of automotive spare parts in terms of executing their strategies and managing their supply chains in an effective and efficient manner.

In the context of supply chain management, the literature has mentioned particular characteristics of spare parts such as the intermittent nature of demand, the multiplicity of references and the risk of obsolescence (Bacchetti and Saccani, 2012). These characteristics complicate the spare parts supply chain management and have a significant influence on all supply chain processes, especially those related to forecasting and inventory management, which directly influence the performance of the spare parts supply chain as a whole.

Therefore, companies that compete in the automotive aftermarket have to go through a performance measurement step in order to determine the impact of their practices, to control the supply chain processes and to assess the extent to which customers' expectations have been fulfilled. The performance measurement of automotive spare parts supply chain will provide many insights about the effects of supply chain strategies and the opportunities to achieve systemic and optimal coordination and synchronization of activities in order to improve business performance.

The literature on spare parts management has principally been limited to inventory management and forecasting methods. Few contributions have focused on the measurement of the spare parts supply chain performance. Even though the literature provides several frameworks for the supply chain performance measurement, the application of the proposed frameworks for the spare parts supply chain performance measurement is almost absent. Even more, the literature lacks performance measurement frameworks designed specifically for the spare parts supply chain and that take into account the particular characteristics of spare parts.

This paper aims to fill this gap, in particular for the automotive aftermarket, by providing a categorization approach that encompasses the required categories and subcategories for the performance measurement of automotive spare parts supply chain. We mainly focus on independent distributor belonging to the independent channel.

This paper is structured as follows: We initially describe the automotive spare parts distribution chain. Then, we provide a literature review that covers performance notions, performance measurement frameworks and spare parts supply chain



management overview. Subsequently, we present the methodology and the proposed framework. Finally, we present our conclusion.

2. Automotive Spare Parts Distribution Chain

The automotive aftermarket is characterized by the presence of several actors who form two main distribution channels: The car manufacturer channel presented in figure 1 and the independent channel presented in figure 2. In both distribution schemas, we do not take into account the suppliers of raw materials and semi-finished products. We start from the supplier of the final product.

The car manufacturer distribution channel includes original equipment manufacturers (OEMs), car manufacturers, dealers, authorized repairers and final customers who are either individual customers or business customers such as insurance companies, fleet owners and car rental companies.

The car manufacturers entrust the manufacturing of more than 60% of original spare parts, intended for the assembly of new vehicles, to OEMs. They usually produce visible spare parts that are legally protected by the design rights. This protection confers monopolies on car manufacturers in the automotive aftermarket, which creates a controversy because such monopolies are accused of harming free competition, increasing prices for consumers and rising insurance premiums. In this context, some countries have opted for the liberalization of the visible spare parts market such as Spain and Italy, unlike other countries such as France, Germany and Sweden, which still hold their monopolies.

The manufacturing of an original spare part by the OEM usually needs a specific tooling designed and/or manufactured by the OEM, or purchased from the tooling manufacturer. A new tooling requires a very heavy investment, so it is usually financed by the car manufacturer. The relationship between the car manufacturer and the OEM is based on a contract that provides the conditions of tooling utilization. The contract usually limits the OEM's ability to produce the aftermarket spare parts for the independent channel. It may prohibit the use of the tooling, except with prior authorization of the car manufacturer or fee payment. Otherwise, it may impose an exclusive supply to the car manufacturer who will sell the aftermarket spare parts through the car manufacturer distribution channel for a limited period. Once the contract is expired, the OEM can manufacture and sell the aftermarket spare parts to the car manufacturer and the independent distributors. The aftermarket spare parts manufactured by the OEM have nearly the same features as the original spare parts.

The independent distribution channel is a multilevel distribution system. It includes equipment manufacturers, independent distributors, wholesalers, retailers, independent repairers, service stations, independent body shops and final customers who are either individual customers or business customers.

The equipment manufacturers are OEMs, manufacturers of good quality spare parts, but of lower quality than OEMs' spare parts, which perform the function



needed to operate the car. There are also some small and medium-sized companies that manufacture cheap and poor quality spare parts.

The independent distributors sell different types and brands of automotive spare parts to wholesalers through their shops. They may directly sell spare parts to retailers, independent repairers and business customers such as insurance companies, fleet owners and car rental companies.

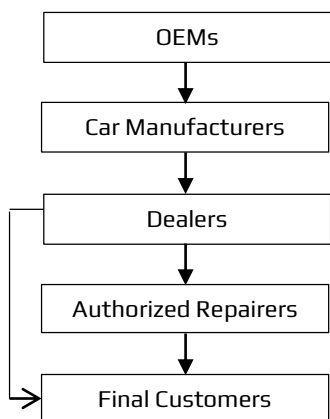


Figure 1. Car manufacturer distribution channel

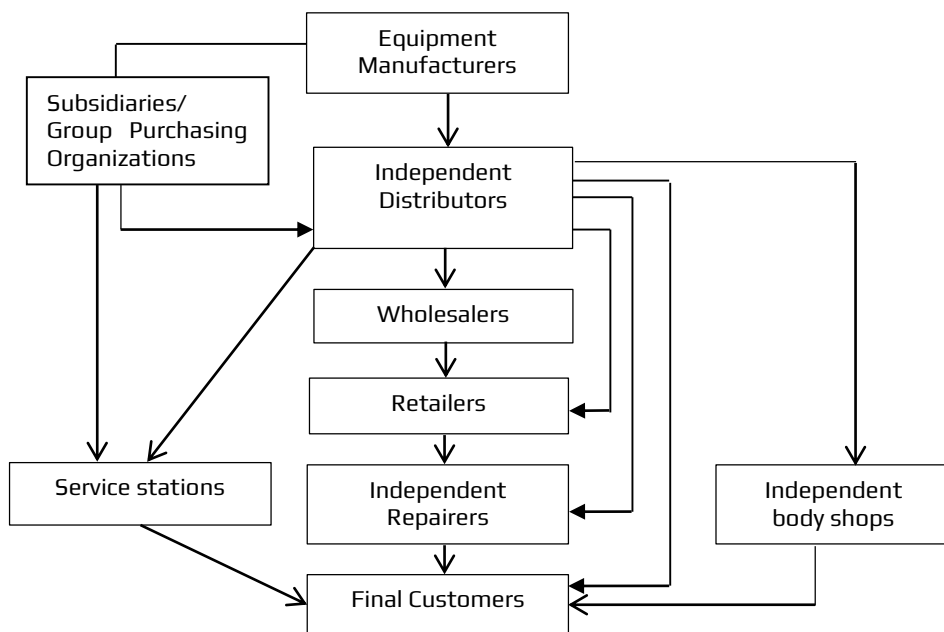


Figure 2. Independent distribution channel

3. Literature Review

3.1. Concepts and Notions

The literature has presented several definitions of the word “performance”. For example, Bourguignon (1995) proposed the following definitions:

- 1- Performance is a variable success according to companies and actors.



2- Performance is the result of an action. It represents the degree of achievement of objectives.

3- Performance is an action, or even a process that leads to success.

Laitinen (2002) defined performance as the ability of an entity, an individual, a group or an organization to achieve specific objectives through a number of activities. Berrah (2013) also pointed out that a company performs well when the desired objectives are achieved.

The performance analysis has been associated with three fundamental dimensions: Effectiveness, efficiency and relevance.

- Effectiveness is the ability of a company to achieve the desired objectives;
- Efficiency is the ability of a company to achieve the desired objectives by using fewer resources;
- Relevance is the adequacy between the desired objectives and the means used to achieve them.

The literature has also presented several definitions of the performance measurement system. Franco-Santos et al. (2007) examined a set of definitions introduced in the literature by different researchers representing various research disciplines (strategy, operations, finance, accounting, human resources management, etc.). Their analysis led to a classification of different definitions into three perspectives. The operational perspective based on the use of several metrics to quantify effectiveness and efficiency as introduced by Neely et al. (1995). The strategic perspective, which considers performance measurement system as a tool for aligning strategic goals with processes (Ittner et al., 2003). The accounting perspective suggested by Otley (1999), which considers performance measurement system as a tool for planning and budgeting the performance and the outcomes.

The performance measurement system plays a very important role due to its major functions that are beneficial to companies. It encompasses a set of measures that enable managers to control processes and to make decisions in order to improve business performance and achieve organizational excellence.

The complexity of automotive spare parts supply chain requires manufacturers and distributors of automotive spare parts to have effective performance measurement systems to better perform in the automotive aftermarket. In this context, we propose a framework for the independent distributor of automotive spare parts that will lead to the measurement of the overall automotive spare parts supply chain performance.

3.2. Performance Measurement Frameworks

Several performance measurement systems have been proposed in the literature (Chan et al., 2006). Initially, the performance measurement was limited to financial measures (e.g. return on investment and profit). Over time, it turned out that financial measures were not sufficient because of the complexity of certain supply chains that require innovation and continuous improvement. It has been necessary



to integrate non-financial measures, such as operational measures and long-term parameters related to strategic planning.

In this context, several authors have pointed out the importance of integrating non-financial measures into performance measurement systems (Medori and Steeple, 2000) and the importance of discussing the financial measures proposed in the literature (Ittner and Larcker, 1998). Activities and processes have also been considered as relevant aspects of performance (Johnson and Kaplan, 1987; Demeestère et al., 1997).

Table 1 presents a literature review of performance measurement frameworks that was carried out through a process of articles selection presented in figure 3. The selected frameworks have presented the major developments of performance measurement since 1990. They have incorporated new performance dimensions such as productivity, responsiveness, leadership, innovation and personal improvement.

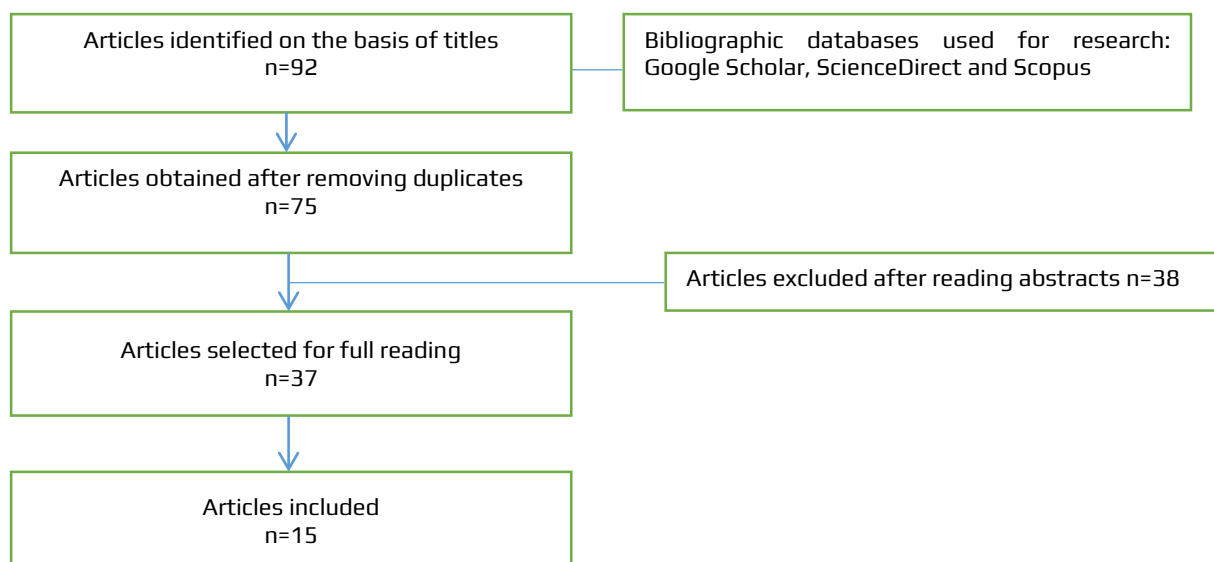


Figure 3. Process of articles selection

The process of articles selection led to the most relevant contributions that fall within the scope of this paper. However, the number of articles included attests the scarcity of contributions that provide categorization approaches for evaluating the overall supply chain performance.

Table 1. A Selected Literature Review of Performance Measurement Systems

Framework	Author(s)	Dimension(s)	Description
Economic Value Added	Stewart (1991)	Financial performance	The framework proposes a financial performance measure called economic value added (EVA) that allows assessing the true economic profit of a company and aligns decision making with the shareholder wealth.
Results and Determinants framework	Fitzgerald et al. (1991)	Financial success, competitiveness, flexibility, resource utilization, quality, innovation	The framework provides six dimensions that are linked to strategic plans. Two dimensions are the results of the strategy: Competitiveness and financial success. The other dimensions are the determinants of the strategic success.
Performance Pyramid	Lynch and Cross (1991)	Market, financial performance, customer satisfaction, flexibility, productivity, quality, time, delivery, waste	The framework includes a hierarchy of financial and non-financial performance measures that link the hierarchical view of business performance measurement to the business process view.
EFQM – Excellence model	EFQM (1991)	Leadership, people, strategy, partnership and resources, processes, people results, customer results, society results, business results	It is a practical and non-prescriptive framework designed to improve business performance through the self-assessment. The framework is based on nine criteria, five are called enablers and four are called results. Enablers are improved through results.
Balanced Scorecard	Kaplan and Norton (1992)	Financial perspective, customer perspective, business process perspective, innovation and learning perspective	The model translates a company vision and strategy into a set of objectives and measures through four perspectives. The aim of the framework is to create a balance between financial and non-financial measures, short-term and long-term objectives, internal and external performance.
Integrated Dynamic performance measurement system	Ghalayini et al. (1997)	Financial performance, customer satisfaction, quality, delivery, process technology, education and training, time	The model is developed for manufacturing companies. It integrates three main areas of the company: Management, process improvement team and factory shop floor. The three areas are linked through the specification, reporting and dynamic updating of defined areas of success, performance measures and performance standards.
Integrated performance measurement framework	Medori and Steeple (2000)	Quality, cost, flexibility, time, delivery, future growth	The integrated framework is developed in order to audit and enhance performance measurement systems through some competitive dimensions.
Performance Prism	Neely et al. (2001)	Stakeholder satisfaction, stakeholder contribution, strategies, processes, capabilities	It is a measurement framework with a comprehensive stakeholder orientation. The management teams can use it to orient their thinking about the key questions to address when seeking to manage their business.
Kanji's Business Scorecard	Kanji and e Sá (2002)	Stakeholder values, process excellence, organizational learning, delighting stakeholders	The model is developed in order to overcome the limitations of the Balanced Scorecard. It helps companies to achieve process excellence, organizational values and stakeholders' satisfaction.
Dynamic multidimensional performance framework	Maltz et al. (2003)	Financial, market, process, people, future	The framework integrates people development and future measures into the Balanced Scorecard perspectives in order to assess and improve the organizational success.
Holistic Scorecard	Sureshchandar and Leisten (2005)	Financial perspective, customer perspective, business process perspective, intellectual capital perspective, employee perspective, social perspective	The model is an integrated scorecard for measuring and managing business performance in the software industry. It encompasses six perspectives of performance, as well as critical success factors and key performance indicators.
Total Performance Scorecard	Rampersad (2005)	Financial perspective, customer perspective, internal perspective, knowledge and learning perspective, personal improvement, process improvement	The framework combines the goals and aspirations of the individual with those of the company. It integrates Personal Balanced Scorecard and Organizational Balanced Scorecard with PDCA cycle (plan, do, check and act), Kolb's learning cycle and talent development cycle.

Table 1. A Selected Literature Review Of Performance Measurement Systems (continued)

Framework	Author(s)	Dimension(s)	Description
LogistiQual	Grimaldi and Rafele (2007)	Tangible components, ways of fulfillment, informative actions	The framework is based on SERVQUAL model (Parasuraman et al., 1985) that proposes five dimensions for the service quality evaluation: Tangibles (physical facilities, equipment, personnel and communication), reliability, responsiveness, assurance and empathy. These dimensions have been the starting point of LogistiQual framework that includes three macro-classes: -Tangible components macro-class that encompasses internal and external assets (physical instruments, operative means, handling, warehousing, transport), personnel aspects, inventory and availability aspects; -Ways of fulfillment macro-class that includes the ways and parameters for carrying out the service, such as flexibility, lead time, supply conditions and service care; -Informative actions macro-class that includes marketing, order management, after-sales, e-information and communication with customers about the service activities. Two subclasses were later included: Internal communication in the order management class and forecasting in the marketing class.
"System Dynamics-based" Balanced Scorecard	Barnabè (2011)	Financial perspective, customer perspective, internal process perspective, learning and growth perspective	The framework provides a mapping tool for a comprehensive strategy map design. It combines the traditional Balanced Scorecard and the system dynamics principles for strategic management decisions.
Supply Chain Operations Reference model - SCOR	Supply Chain Council (2012)	Reliability, agility, responsiveness, costs and assets	The SCOR model was originally developed in 1996, in order to analyze and describe the processes along the entire supply chain, as well as to measure and improve the supply chain performance. The model provides an approach, processes, indicators and best practices to represent, evaluate and diagnose a supply chain. It integrates the concepts of business process reengineering to model the current situation, benchmarking to position the company in its competitive environment and process measurement into a cross-functional framework. The recent version of the framework "SCOR 12.0" covers six processes: Plan, source, make, deliver, return and enable. It also includes new training information and integrated sustainability standards.

The literature has presented several performance measurement systems that combine financial and non-financial performance dimensions. Social and environmental dimensions have also been taken into account (Figge et al., 2002; Lämsiluoto and Järvenpää, 2008) and some management terms have emerged such as corporate social responsibility and sustainability.

However, the proposed frameworks do not evaluate the overall supply chain performance (Gunasekaran et al., 2001; Lambert and Pohlen, 2001). It is therefore important to focus on the performance of the supply chain as a whole, since a weak link in the supply chain leads to the degradation of its overall performance. It is particularly important in those contexts where supply chain is considered a key factor of corporate success (Olugu et al., 2011).



3.3. Spare Parts Supply Chain Management Overview

The particular characteristics of spare parts have prompted several researchers to focus mainly on spare parts inventory management and forecasting methods. However, the literature dealing with spare parts supply chain performance measurement is still very limited (see table 2).

Table 2. Summary Of Contributions Related To Spare Parts Supply Chain Management

Research field	Main purpose of publications	Authors
Inventory management	-Mathematical approaches to optimize spare parts inventory management -Obsolescence management -Order and stocking policies -Inventory control -Inventory levels	Scudder (1984), Cobbaert and Van Oudheusden (1996), Dekker et al. (1998), Kennedy et al. (2002), Teunter and Klein Haneveld (2002), Kalchschmidt et al. (2003), Aronis et al. (2004), Caglar et al. (2004), Chang et al. (2005), Wong et al. (2005), Porras and Dekker (2008)
	Spare parts classification	Gajpal et al. (1994), Partovi and Anandarajan (2002), Braglia et al. (2004), Zhou and Fan (2007), Ramanathan (2006), Ng (2007), Boylan et al. (2008)
Demand forecasting	Forecasting methods to predict spare parts demand	Eaves and Kingsman (2004), Willemain et al. (2004), Hua et al. (2007), Boylan and Syntetos (2008), Romeijnders et al. (2012), Bacchetti and Saccani (2012), Hemeimat et al. (2016), Zhu et al. (2017)
	Forecasting automotive spare parts demand	Yang and Chen (2012), Do Rego and De Mesquita (2015)
Supply chain performance measurement	Performance measures used by aftermarket suppliers	Barkawi and Partners GmbH (2002), De Leeuw and Beekman (2008)
	After-sales service performance measurement	Gaiardelli et al. (2007)

The overview shows that there is still a need for the development of performance measurement systems for the spare parts supply chain. The research has focused on the identification of the key performance indicators used by aftermarket suppliers. Barkawi and Partners GmbH (2002) identified a set of key performance indicators used by some providers of spare parts, namely: On-time delivery performance, inventory turnover, service level, availability rate, accuracy of delivery, accuracy of forecasts, inventory level, complaint rate and customer satisfaction. De Leeuw and Beekman (2008) investigated some companies belonging to the car manufacturer channel. They provided a set of key performance indicators that were important according to the interviewees, namely: Availability rate, stock-out, lead time, delivery frequency, completeness, correctness, regularity and punctuality. The investigation was based on the application of the LogistiQual model (see table 1).

The overview also includes the after-sales service performance measurement as it incorporates the spare parts logistics performance. Gaiardelli et al. (2007) proposed an integrated framework for the after-sales service performance measurement. The framework was evaluated through multiple-case studies including the automotive sector. The authors provided several key performance indicators for spare parts logistics performance measurement, such as error rate, picking time, delivery time, inventory obsolescence, supplier delivery performance, supplier quality performance and number of stock-outs per month.

We confirm the importance of the performance measures provided by the authors given the particular characteristics of spare parts and the high expectations of customers in terms of service quality and availability of spare parts. However, it is essential to take into account other performance measures for effective spare parts supply chain performance measurement.



4. Methodology and Framework

As already mentioned, the performance measurement systems proposed in the literature do not combine several dimensions and do not evaluate the overall supply chain performance. Besides, the contributions related to spare parts supply chain performance measurement are very limited.

Thus, the present paper aims to fill the gap existing in the literature by providing a balanced and multidimensional categorization approach for the performance measurement of automotive spare parts supply chain (see table 3). The categorization approach encompasses the performance categories and subcategories for all supply chain links, information system performance, research and development performance, human capital performance, as well as financial performance all over the supply chain. This categorization approach will lead to the measurement of the overall supply chain performance that we define as follows: "The overall performance of automotive spare parts supply chain is the ability to generate, at the same time, financial profitability and customer satisfaction and loyalty, by challenging competitors in terms of service quality, innovation and operational efficiency".

The identification of categories and subcategories was partly based on the previous literature review and partly on our personal reasoning and on the judgments of industrial experts and managers met during a year-long internship at a leading automotive spare parts distribution company in Morocco.

Table 3. Performance Measurement Framework For Automotive Spare Parts Supply Chain

Aspect	Category	Subcategory	Subcategory definition
Customer service performance	Service quality	Responsiveness	Responsiveness means the ability of employees to provide prompt service to the customer. It encompasses the speed of response to the customer through the various communication channels (phone, e-mail, social network, website and fax), the speed of order processing, the speed of solving claims and business disputes, the speed of information transmission to the customer and the speed of information sharing between employees.
		Accessibility	Accessibility means the ease of contact with the company through the various communication channels. It also includes the geographic coverage of the company stores.
		Reliability	Reliability means that order processing and claims solving are done correctly and timely. It also means the availability of communication channels, the absence of problems and business disputes, the accuracy of information provided to customers and the accuracy of information shared between employees.
	Customer relationship management	Customer satisfaction	Customer satisfaction is a positive feeling that customers have when the quality of service meets their expectations. It is assessed through survey questions and other means to analyze customers' opinions regarding the understanding and the identification of their needs, the respect of their requirements and the response to their expectations.
		Customer loyalty	Customer loyalty means creating and maintaining a long lasting relationship with customers by creating a climate of trust. It is conditioned by the knowledge of customers and the implementation of an action plan based on the analysis of customers' expectations and claims, as well as on the analysis of competition.
	Administrative productivity	Administrative activity level	The level of administrative activity expresses the amount of administrative work executed, namely: Order processing through the various communication channels, the creation of customers' accounts and the reminder of unpaid invoices.
		Administrative growth	Administrative growth means the evolution of the administrative productivity, compared to a previous period and considering the desired objectives.

Table 3. Performance Measurement Framework For Automotive Spare Parts Supply Chain (continued)

Aspect	Category	Subcategory	Subcategory definition
Customer service performance	Commercial productivity	Commercial activity level	The level of commercial activity expresses the amount of commercial work carried out, namely: Prospecting and acquisition of new customers, the writing of sales pitch, the sales follow-up and the elaboration of commercial action plans.
		Commercial growth	Commercial growth means the evolution of the commercial productivity, compared to a previous period and considering the desired objectives. We note that the turnover is a financial result of the executed commercial work.
		Customer activity	The customer activity reflects the volatility of customers' purchasing behavior and their reactions following commercial and marketing solicitations.
		Forecast achievement	The measurement of forecast achievement consists in a comparison between the obtained results and the forecast in terms of turnover, market share and number of customers.
		Sales forecasting accuracy	The sales forecasting accuracy expresses the difference between the sales forecasting and the realized sales. It enables managers to know the capacity of forecasting to anticipate customers' demand in order to ensure the availability of spare parts. It also helps in decision-making for the continuous improvement of the sales forecasting process.
		Promotional action	The promotional action serves a multitude of purposes, namely: To attract the attention of customers and push them to purchase in order to increase sales temporarily, to retain customers by offering temporary financial benefits, to reactivate inactive customers and to conquer new customers by facilitating their first purchases.
Warehouse performance	Capacity	Logistics infrastructure	Logistics infrastructure includes central warehouses, regional stores and logistics platforms used for the distribution and sale of spare parts.
		Warehouse equipment	It includes the material handling equipment and other equipment used for the execution of warehousing and cross-docking operations.
		Infrastructure utilization	It means the degree to which central warehouses areas, regional stores areas and logistics platforms areas are exploited regarding their total surface areas.
		Equipment utilization	It means the degree to which the material handling equipment and other equipment are used to carry out the warehousing and cross-docking operations.
	Service quality	Responsiveness	Responsiveness means the ability of employees to execute promptly the warehousing operations, namely: Spare parts reception, storage, preparation of customers' orders, preparation of periodic replenishments of regional stores, preparation of spare parts to transfer from a central warehouse to a regional store or from a regional store to another, and shipment operations. Responsiveness also includes the speed of cross-docking operations execution, the speed of solving problems and business disputes, and the speed of information sharing between employees.
		Service reliability	Service reliability means that the warehousing and cross-docking operations are carried out rigorously and timely. It also means the accuracy of information shared between employees and the absence of problems and business disputes.
		Equipment reliability	It means the ability of the material handling equipment and other equipment to perform the warehousing and cross-docking operations under given conditions and at the desired time.
		Items security	It means the degree of protection of spare parts against the unknown shrinkage (loss, undetected errors of inventory transactions recording, etc.) and the known shrinkage (damage during handling, deterioration following bad storage, etc.).
	Operational productivity	Operational activity level	The level of operational activity expresses the amount of operational work performed by employees.
		Operational growth	Operational growth means the evolution of the operational productivity, compared to a previous period and considering the desired objectives.

Table 3. Performance Measurement Framework For Automotive Spare Parts Supply Chain (continued)

Aspect	Category	Subcategory	Subcategory definition
Stock & procurement performance	Service quality	Availability	Availability means the presence and sufficiency of items in stock at the time of order.
		Procurement plans reliability	The reliability of procurement plans means the ability of procurement methods to identify the optimal order quantities and the dates for placing the purchase orders. It also means the degree of achievement of established procurement plans.
	Activity level	Inventory turnover	Inventory turnover means the stock periodic renewal. Certainly, a high inventory turnover reflects the high level of sales and the effectiveness of inventory management practices.
		Stock coverage	Stock coverage is the ability of the stock to fulfill customers' orders for a specified period, through an immediate availability of spare parts without replenishment or stock-out.
		Stock level	Stock level refers to different levels of stock (safety stock, maximum stock level, minimum stock level, etc.). These levels are related to customers' needs and consumption.
	Control and tracking	Inventory transactions accuracy	It means the accuracy and rigor of real time inventory transactions recording.
		Stock-taking	The stock-taking consists in identifying and evaluating, in a rigorous and planned way, the quantity of spare parts physically present in a stock at a given moment. It allows determining the differences between the theoretical quantities, recorded in an ERP or in inventory management software, and the actual quantities determined by the physical counting teams.
	Delivery performance	Capacity	Material resources
Utilization			It means the degree to which internal and external road transport means are used regarding the capacity of each mean of transport.
Service quality		Responsiveness	Responsiveness means the ability of the company to provide quick spare parts deliveries to customers and to regional stores.
		Reliability	Reliability means that deliveries to customers and regional stores are done correctly and at the right time. It also means the accuracy of transport documents and the availability of internal and external road transport means.
		Items security	It means the degree of protection of spare parts against loss and deterioration during delivery.
		Organization	The delivery organization includes planning, scheduling and optimization of delivery process through the massification and rationalization of flows. The delivery organization saves time and leads to better customer service and costs reduction of delivery rounds, while respecting company and customers' constraints.
Operational productivity		Operational activity level	The level of operational activity expresses the amount of operational work executed.
		Operational growth	Operational growth means the evolution of the operational productivity, compared to a previous period and considering the desired objectives.
Purchasing performance	Supplier service quality	Responsiveness	Responsiveness means the supplier's ability to provide prompt service to the company. It encompasses the speed of response to the purchaser through the various communication channels, the speed of order confirmation and order processing, the speed of solving claims and business disputes, and the speed of information transmission to the purchaser.
		Accessibility	Accessibility means the ease of contact with suppliers through the various communication channels. It also includes the geographic proximity of suppliers.
		Reliability	Reliability means that order processing, claims processing and delivery are done correctly and timely. It also means the availability of communication channels, the accuracy of information transmitted to the purchaser and the absence of business disputes.

Table 3. Performance Measurement Framework For Automotive Spare Parts Supply Chain (continued)

Aspect	Category	Subcategory	Subcategory definition
Purchasing performance	Customs and transit service quality	Responsiveness	Responsiveness means, on the one hand, the ability of the customs administration to carry out promptly the customs procedures and, on the other hand, the ability of the forwarding agent to provide prompt service to the company.
		Reliability	Reliability means that the services provided by the forwarding agent and the customs administration are carried out correctly and timely.
	Internal service quality	Responsiveness	Responsiveness means the purchaser's ability to respond promptly to the needs of the internal customer. It includes the speed of placing orders, the speed of purchasing accomplishment, the speed of claims transmission to suppliers, the speed of information transmission to the internal customer and the speed of solving problems and business disputes.
		Reliability	Reliability means that the purchaser responds to the needs of the internal customer at the right time and ensures the arrival of compliant goods and correct transport documents. It also means the accuracy of the information provided to the internal customer and the absence of problems and business disputes.
		Internal customer satisfaction	Internal customer satisfaction is a positive feeling that the internal customer has when the purchasing service quality meets his expectations. It is assessed through survey questions and other means to analyze the internal customer's opinion.
	Administrative productivity	Sourcing	The sourcing means to look for new suppliers who are able to respond effectively to the needs of the company in terms of cost, quality, time, innovation and payment terms.
		Purchasing activity	Purchasing activity includes issuing orders and completing purchases. It is reflected in the value of purchases made and in the percentage of active suppliers.
		Orders follow-up	The administrative follow-up of orders consists, on the one hand, in checking if the acknowledgement of receipt sent by the supplier is consistent with the order placed in terms of price, quantity and spare parts references and, on the other hand, in relaunching the supplier in case of delay or in case of close delivery for the one who does not often respect the delivery date.
		Purchasing activity growth	It means the evolution of the purchasing activity, compared to a previous period and considering the desired objectives.
	Reverse logistics performance	Service quality	Responsiveness
Accessibility			Accessibility means the ease of contact with the after-sales service through the various communication channels.
Service reliability			Service reliability means that the claims processing and returns processing are carried out correctly and timely. It also means the availability of communication channels, the absence of problems and business disputes, the accuracy of information provided to customers and the accuracy of information shared between employees.
Equipment reliability			It means the ability of intervention equipment to operate without any break down, in order to carry out the after-sales service interventions under given conditions and at the desired time.
Customer relationship management		Customer satisfaction	Customer satisfaction is a positive feeling that customers have after interacting with the after-sales service. It is assessed through survey questions and other means to analyze customers' opinions regarding the resolution of their claims and the quality of interventions.
		Customer loyalty	Customer loyalty is also conditioned by the particular attention given by the after-sales service to customers, in case of claims and returns of defective spare parts.



Table 3. Performance Measurement Framework For Automotive Spare Parts Supply Chain (continued)

Aspect	Category	Subcategory	Subcategory definition
Reverse logistics performance	Productivity	Operational activity level	The level of operational activity expresses the amount of operational work of the after-sales service.
		Administrative activity level	The level of administrative activity expresses the amount of administrative work of the after-sales service, namely: The reception of claims through the various communication channels, the creation and the follow-up of files related to claims, the writing of interventions reports, the writing and sending of information mails to customers, the follow-up of guarantees and the transmission of defective spare parts state to the involved departments.
		Operational growth	Operational growth means the evolution of operational productivity of the after-sales service, compared to a previous period and considering the desired objectives.
		Administrative growth	Administrative growth means the evolution of administrative productivity of the after-sales service, compared to a previous period and considering the desired objectives.
Information system performance	IT infrastructure	IT resources	IT resources include hardware and software used to access to information.
		Utilization	It means the degree to which IT resources are exploited to manage, process, and store data.
	Information security	Availability	Availability refers to the proper operation of the information system and the access to information at the time of use.
		Integrity	Integrity means maintaining the accuracy of information during its use.
Research & development performance	Monitoring activity	Marketing intelligence	Marketing intelligence consists in collecting, analyzing and transmitting information about the automotive aftermarket and the automotive industry. It encompasses the monitoring of spare parts and vehicles technical evolution, the detection of new spare parts, the monitoring of statistics related to the car fleet circulating in the country as well as the monitoring of customers' financial health.
		Competitive intelligence	Competitive intelligence consists in monitoring competitors and collecting information about their pricing policies, their practices in terms of sale and distribution of automotive spare parts, as well as information about their financial and commercial performances such as turnover, market share, margin rate and number of customers.
		Technology watch	Technology watch means to be informed continuously about the recent technological evolutions and innovations, namely: New warehouses automation technologies, new IT solutions and new security technologies in warehouses and means of transport.
	Innovation	Digital transformation	Digital transformation means the integration of digital technology into all supply chain processes, by investing massively in the information system and the commercial communication system, in order to strengthen the customer relationship quality and to share information between all supply chain actors.
		Commercial innovation	Commercial innovation consists in renewing the offer by introducing new references and targeting new equipment manufacturers. It also includes the development of spare parts distribution network and the adoption of new sale concepts. Commercial innovation enables the independent distributor to deal with the aggressive competition in the automotive aftermarket and to adapt to the changing market dynamics and to customer behavior.
		Logistics innovation	Logistics innovation consists in integrating new strategies and advanced technologies that allow improving logistics performance in terms of time and quality of warehousing and transport operations execution, as well as the improvement of working conditions of logistics operators.
		Organizational innovation	Organizational innovation consists in adopting new practices and approaches for organizing the distribution of spare parts and the work of employees.

Table 3. Performance Measurement Framework For Automotive Spare Parts Supply Chain (continued)

Aspect	Category	Subcategory	Subcategory definition
Human capital performance	Professional skills development	Professional training	Professional training is a learning activity that develops and strengthens the professional skills of employees in order to accomplish their missions and tasks effectively.
		Career mobility	Career mobility refers to the change in the employee's professional situation (change of job or department within the same company, or switching to another company). Career mobility guarantees job security and allows the improvement of the employee's working conditions. It also allows the employee's professional skills development through the various experiences during which the employee shares ideas and practices with other professionals with different profiles.
		Promotion	Promotion means the appointment of the employee to a higher position. It is usually accompanied by a salary increase or other benefits to energize the employee.
		Recruitment	Recruitment is based on a set of actions implemented in order to find the right profile for the needs of the company. The recruitment process ends with the integration of the recruit so that he or she knows the environment of the company, the missions assigned and the future professional relationships.
		Professional skills assessment	The assessment of professional skills consists in evaluating the employee's technical and managerial knowledge, skills, interpersonal behavior and the work executed. It promotes the dialogue between the employee and his or her superior so that the employee can have a visibility on the evolution of his or her career by knowing his or her strengths and weaknesses. It also makes it possible to look for employee's improvement areas and to make decisions regarding remuneration, professional training, new objectives and career mobility.
	Employee well-being	Employee satisfaction	Employee satisfaction is a positive feeling that employees have when the working conditions meet their expectations. It is conditioned by several factors such as the organization of work, the clarity of roles, the workload, the available resources, the business environment and its changes, the job security and the professional relationships. Employee satisfaction is assessed through survey questions and other means to analyze employees' opinions.
		Motivation	Motivation means the willingness to perform a task or to achieve an objective. It can be intrinsic coming from the employee or extrinsic resulting from the incentives of the company such as the improvement of the working conditions, the improvement of management and communication, the professional skills development, the creation and retention of a strong corporate culture, as well as the recognition and reward through bonuses, social benefits and increase of salaries.
		Commitment	Commitment means the devotion of employees to their company in order to achieve the desired goals. It encompasses the presence, the availability, the loyalty and the pride of belonging to the company as well as the employees' desire to invest themselves energetically, enthusiastically and effectively in the work and in the implementation of the action plan in order to achieve the desired goals.
	Human capital security	Work safety	Work safety means the degree of employees' protection against hazards and risks of accidents that may occur during working hours.
		Job security	Job security is the assurance that an employee will not lose his job in the near future. It depends on many factors such as the individual performance, the economic situation and the performance of the company.
		Social protection	Social protection aims to prevent and manage the social risks that affect the well-being of employees (diseases, work accidents, disability, loss of retirement income, etc.).
	Financial performance	Investment	Investment viability
Financing sources			Sources of financing are the internal and external modes adopted by the company to finance an investment. Internal financing refers to self-financing, assets disposal and capital increase, while the external financing involves the resort to the third party funding, intermediaries and financial markets.



Table 3. Performance Measurement Framework For Automotive Spare Parts Supply Chain (continued)

Aspect	Category	Subcategory	Subcategory definition
Financial performance	Financial wealth	Revenues generation	It represents the ratio of revenues generated by the company to resources used to obtain them.
		Profitability	Profitability is the ability of the company to generate profit through its activity.
		Activity growth	The growth of the activity means the evolution of the business activity. It reflects the degree of the activity control and the level of wealth created during a given period. The growth of the activity must result from a good management since it can come from a faster increase of the company expenses, which can generate an increase of indebtedness.
	Financial health	Profit growth	Profit growth means the evolution of the monetary profit generated.
		Solvency	Solvency is the ability of the company to pay short, medium and long-term debts. It is positive when the sum of fixed assets, accounts receivable and inventories is higher than debts.
		Financial indebtedness	Financial indebtedness refers to debts from third party funding (credit institutions, banks, etc.) except suppliers' debts, fiscal and social debts. Financial indebtedness must not exceed a certain level to not generate an inability to repay the lenders, which can lead to a judicial liquidation.
		Liquidity	Liquidity means the ability of the company to pay off short-term debts. This requires the company to have a sufficient amount of cash and assets that can readily be converted into cash.

5. Conclusion

The literature on spare parts management has mainly focused on spare parts inventory management and forecasting methods. But comparatively, little attention has been devoted to the measurement of the spare parts supply chain performance. In this perspective, we tried to fill the gap found in the literature, in particular, for automotive aftermarket by providing a multidimensional and balanced categorization approach in order to measure the automotive spare parts supply chain performance and to assess the impact of practices inside any company operating in the independent distribution of automotive spare parts. In turn, this framework will enable managers to determine weak areas where performance can be improved.

The categorization approach encompasses financial and non-financial categories and subcategories and consequently leads to the measurement of the overall performance of automotive spare parts supply chain. It was based on academic research and experts' judgments, as well as our personal reasoning. We regard the approach to be reliable, well designed and can serve any independent distributor of automotive spare parts since it treats all the links of the supply chain and incorporates both financial and non-financial dimensions for effective supply chain performance measurement.

Given the scarcity of contributions related to spare parts supply chain performance, this paper will constitute a basis for future academic and practitioner research in accordance with the development of the supply chain management.



References

- Aronis, K. -P., Magou, L., Dekker, R. and Tagaras, G. (2004) 'Inventory control of spare parts using a Bayesian approach: A case study', *European Journal of Operational Research*, Vol. 154, No. 3, pp. 730-739.
- Bacchetti, A. and Sacconi, N. (2012) 'Spare parts classification and demand forecasting for stock control: Investigating the gap between research and practice', *Omega*, Vol. 40, No. 6, pp.722-737.
- Barkawi and Partners GmbH (2002) 'Global Study on Spare Parts Logistics', Munich.
- Barnabè, F. (2011) 'A "system dynamics-based Balanced Scorecard" to support strategic decision making', *International Journal of Productivity and Performance Management*, Vol. 60, No. 5, pp. 446-473.
- Berrah, L. (2013) 'La quantification de la performance dans les entreprises manufacturières : de la déclaration des objectifs à la définition des systèmes d'indicateurs', *Informatique [cs]*, Université de Savoie (Doctoral dissertation).
- Bourguignon, A. (1995) 'Peut-on définir la performance ?', *Revue française de comptabilité*, Vol. 269, pp. 61-66.
- Boylan, J. E., Syntetos, A. A. and Karakostas, G. C. (2008) 'Classification for forecasting and stock control: a case study', *Journal of the Operational Research Society*, Vol. 59, No. 4, pp. 473-481.
- Boylan, J. E. and Syntetos, A. A. (2008) 'Forecasting for inventory management of service parts', in *Complex System Maintenance Handbook*, Springer Series in Reliability Engineering, Springer, London, pp. 479-506.
- Braglia, M., Grassi, A. and Montanari, R. (2004) 'Multi-attribute classification method for spare parts inventory management', *Journal of Quality in Maintenance Engineering*, Vol. 10, No. 1, pp. 55-65.
- Caglar, D., Li, C. -L. and Simchi-Levi, D. (2004) 'Two-echelon spare parts inventory system subject to a service constraint', *IIE Transactions*, Vol. 36, No. 7, pp. 655-666.
- Chan, F. T. S., Chan, H. K. and Qi, H. J. (2006) 'A review of performance measurement systems for supply chain management', *International Journal of Business Performance Management*, Vol. 8, Nos. 2-3, pp.110-131.
- Chang, P. -L., Chou, Y. -C. and Huang, M. -G. (2005) 'A (r, r, Q) inventory model for spare parts involving equipment criticality', *International Journal of Production Economics*, Vol. 97, No. 1, pp. 66-74.
- Cobbaert, K. and Van Oudheusden, D. (1996) 'Inventory models for fast moving spare parts subject to "sudden death" obsolescence', *International Journal of Production Economics*, Vol. 44, No. 3, pp. 239-248.
- De Leeuw, S. and Beekman, L. (2008) 'Supply chain-oriented performance measurement for automotive spare parts', *International Journal of Automotive Technology and Management*, Vol. 8, No. 1, pp. 56-70.
- Dekker, R., Kleijn, M. J. and De Rooij, P. J. (1998) 'A spare parts stocking policy based on equipment criticality', *International Journal of Production Economics*, Vol. 56-57, pp. 69-77.
- Demeestère, R., Lorino, P. and Mottis, N. (1997) 'Contrôle de gestion et pilotage', Nathan, Paris.
- Do Rego, J. R. and De Mesquita, M. A. (2015) 'Demand forecasting and inventory control: A simulation study on automotive spare parts', *International Journal of Production Economics*, Vol. 161, pp. 1-16.
- Eaves, A. H. C. and Kingsman, B. G. (2004) 'Forecasting for the ordering and stock-holding of spare parts', *Journal of the Operational Research Society*, Vol. 55, No. 4, pp. 431-437.
- EFQM (1991), *The Business Excellence Model*, EFQM Publication, Brussels.
- Figge, F., Hahn, T., Schaltegger, S. and Wagner, M. (2002) 'The Sustainability Balanced Scorecard – linking sustainability management to business strategy', *Business Strategy and the Environment*, Vol. 11, No. 5, pp. 269-284.



- Fitzgerald, L., Johnston, R., Brignall, S., Silvestro, R. and Voss, C. (1991) 'Performance Measurement in Service Businesses', The Chartered Institute of Management Accountants.
- Franco-Santos, M., Kennerley, M., Micheli, P., Martinez, V., Mason, S., Marr, B., Gray, D. and Neely, A. (2007) 'Towards a definition of a business performance measurement system', *International Journal of Operations & Production Management*, Vol. 27, No. 8, pp. 784-801.
- Gaiardelli, P., Saccani, N. and Songini, L. (2007) 'Performance measurement systems in after-sales service: an integrated framework', *International Journal of Business Performance Management*, Vol. 9, No. 2, pp. 145-171.
- Gajpal, P. P., Ganesh, L. S. and Rajendran, C. (1994) 'Criticality analysis of spare parts using the analytic hierarchy process', *International Journal of Production Economics*, Vol. 35, Nos. 1-3, pp. 293-297.
- Ghalayini, A. M., Noble, J. S. and Crowe, T. J. (1997) 'An integrated dynamic performance measurement system for improving manufacturing competitiveness', *International Journal of Production Economics*, Vol. 48, No. 3, pp. 207-225.
- Grimaldi, S. and Rafele, C. (2007) 'Current applications of a reference framework for the supply chain performance measurement', *International Journal of Business Performance Management*, Vol. 9, No. 2, pp. 206-225.
- Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001) 'Performance measures and metrics in a supply chain environment', *International Journal of Operations & Production Management*, Vol. 21, Nos. 1-2, pp.71-87.
- Hemeimat, R., Al-Qatawneh, L., Arafeh, M. and Masoud, S. (2016) 'Forecasting Spare Parts Demand Using Statistical Analysis', *American Journal of Operations Research*, Vol. 6, No. 2, pp. 113-120.
- Hua, Z. S., Zhang, B., Yang, J. and Tan, D. S. (2007) 'A new approach of forecasting intermittent demand for spare parts inventories in the process industries', *Journal of the Operational Research Society*, Vol. 58, No. 1, pp. 52-61.
- Ittner, C. D. and Larcker, D. F. (1998) 'Are Nonfinancial Measures Leading Indicators of Financial Performance? An Analysis of Customer Satisfaction', *Journal of Accounting Research*, Vol. 36, pp. 1-35.
- Ittner, C. D., Larcker, D. F. and Randall, T. (2003) 'Performance implications of strategic performance measurement in financial services firms', *Accounting, Organizations and Society*, Vol. 28, Nos. 7-8, pp. 715-741.
- Johnson, H. T. and Kaplan, R. S. (1987) 'Relevance Lost: The rise and fall of management accounting', Harvard Business School Press, Boston, MA.
- Kalchschmidt, M., Zotteri, G. and Verganti, R. (2003) 'Inventory management in a multi-echelon spare parts supply chain', *International Journal of Production Economics*, Vol. 81-82, pp. 397-413.
- Kanji, G. K. and e Sá, P. M. (2002) 'Kanji's Business Scorecard', *Total Quality Management*, Vol. 13, No. 1, pp. 13-27.
- Kaplan, R. S. and Norton, D. P. (1992) 'The balanced scorecard: Measures that drive performance', *Harvard Business Review*, Vol. 70, No. 1, pp. 71-79.
- Kennedy, W. J., Patterson, J. W. and Fredendall, L. D. (2002) 'An overview of recent literature on spare parts inventories', *International Journal of Production Economics*, Vol. 76, No. 2, pp. 201-215.
- Laitinen, E. K. (2002) 'A dynamic performance measurement system: evidence from small Finnish technology companies', *Scandinavian Journal of Management*, Vol. 18, No. 1, pp. 65-99.
- Lambert, D. M. and Pohlen, T. L. (2001) 'Supply Chain Metrics', *International Journal of Logistics Management*, Vol. 12, No. 1, pp. 1-19.
- Lämsiluoto, A. and Järvenpää, M. (2008) 'Environmental and performance management forces: Integrating "greenness" into balanced scorecard', *Qualitative Research in Accounting and Management*, Vol. 5, No. 3, pp. 184-206.
- Lynch, R. L. and Cross, K. F. (1991) *Measure Up - The Essential Guide to Measuring Business Performance*, Mandarin, London.



- Maltz, A. C., Shenhar, A. J. and Reilly, R. R. (2003) 'Beyond the Balanced Scorecard: Refining the Search for Organizational Success Measures', *Long Range Planning*, Vol. 36, No. 2, pp. 187-204.
- Medori, D. and Steeple, D. (2000) 'A framework for auditing and enhancing performance measurement systems', *International Journal of Operations & Production Management*, Vol. 20, No. 5, pp. 520-533.
- Neely, A., Gregory, M. and Platts, K. (1995) 'Performance measurement system design: A literature review and research agenda', *International Journal of Operations & Production Management*, Vol. 15, No. 4, pp. 80-116.
- Neely, A., Adams, C. and Crowe, P. (2001) 'The performance prism in practice', *Measuring Business Excellence*, Vol. 5, No. 2, pp. 6-13.
- Ng, W. L. (2007) 'A simple classifier for multiple criteria ABC analysis', *European Journal of Operational Research*, Vol. 177, No. 1, pp. 344-353.
- Olugu, E. U., Wong, K. Y. and Shahraroun, A. M. (2011) 'Development of key performance measures for the automobile green supply chain', *Resources, Conservation and Recycling*, Vol. 55, No. 6, pp. 567-579.
- Otley, D. (1999) 'Performance management: a framework for management control systems research', *Management Accounting Research*, Vol. 10, No. 4, pp. 363-382.
- Parasuraman, A., Zeithaml, V. A. and Berry, L. L. (1985) 'A conceptual model of service quality and its implications for future research', *Journal of Marketing*, Vol. 49, No. 4, pp. 41-50.
- Partovi, F. Y. and Anandarajan, M. (2002) 'Classifying inventory using an artificial neural network approach', *Computers & Industrial Engineering*, Vol. 41, No. 4, pp. 389-404.
- Porras, E. and Dekker, R. (2008) 'An inventory control system for spare parts at a refinery: An empirical comparison of different re-order point methods', *European Journal of Operational Research*, Vol. 184, No. 1, pp. 101-132.
- Ramanathan, R. (2006) 'ABC inventory classification with multiple-criteria using weighted linear optimization', *Computers & Operations Research*, Vol. 33, No. 3, pp. 695-700.
- Rampersad, H. K. (2005) 'Total performance scorecard: the way to personal integrity and organizational effectiveness', *Measuring Business Excellence*, Vol. 9, No. 3, pp. 21-35.
- Romeijnders, W., Teunter, R. and van Jaarsveld, W. (2012) 'A two-step method for forecasting spare parts demand using information on component repairs', *European Journal of Operational Research*, Vol. 220, No. 2, pp. 386-393.
- Scudder, G. D. (1984) 'Priority Scheduling and Spares Stocking Policies for a Repair Shop: The Multiple Failure Case', *Management Science*, Vol. 30, No. 6, pp. 739-749.
- Stewart, G. B. (1991) 'The Quest for Value: A Guide for Senior Managers', Harper Business, New York, NY.
- Supply Chain Council (2012). 'Supply chain operations reference model', Overview of SCOR version 11.0.
- Sureshchandar, G. S. and Leisten, R. (2005) 'Holistic scorecard: strategic performance measurement and management in the software industry', *Measuring Business Excellence*, Vol. 9, No. 2, pp. 12-29.
- Teunter, R. H. and Klein Haneveld, W. K. (2002) 'Inventory control of service parts in the final phase', *European Journal of Operational Research*, Vol. 137, No. 3, pp. 497-511.
- Willemain, T. R., Smart, C. N. and Schwarz, H. F. (2004) 'A new approach to forecasting intermittent demand for service parts inventories', *International Journal of Forecasting*, Vol. 20, No. 3, pp. 375-387.
- Wong, H., Cattrysse, D. and Van Oudheusden, D. (2005) 'Stocking decisions for repairable spare parts pooling in a multi-hub system', *International Journal of Production Economics*, Vol. 93-94, pp. 309-317.
- Yang, Q. and Chen, Y. (2012) 'Auto parts demand forecasting based on nonnegative variable weight combination model in auto aftermarket', *International Conference on Management Science and Engineering 19th Annual Conference Proceedings*, pp. 817-822.
- Zhou, P. and Fan, L. (2007) 'A note on multi-criteria ABC inventory classification using weighted linear optimization', *European Journal of Operational Research*, Vol. 182, No. 3, pp. 1488-1491.



Zhu, S., Dekker, R., van Jaarsveld, W., Renjie, R. W. and Koning, A. J. (2017) 'An improved method for forecasting spare parts demand using extreme value theory', *European Journal of Operational Research*, Vol. 261, No. 1, pp. 169-181.

