SUPPLY NETWORK DESIGN DECISIONS AND SERVICE QUALITY: INSIGHTS FROM PAINT MANUFACTURING FIRMS

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ABSTRACT

This study examined the connection between supply network design decisions and service quality of paint manufacturing firms in Rivers State. The study adopted a correlational research design and collected primary data via cross-sectional survey, using structured questionnaire. The Pearson Product Moment correlation served as the test statistic, relying on the statistical package for social sciences (SPSS) version 23.0. The study found that supply network design decisions (facility location, transportation mode and vehicle routing) have strong, positive and statistically significant association with service quality, with transportation mode and service quality having the strongest link. The study concluded that supply network design decisions inform service quality of paint manufacturing firms in Rivers State, and that service quality of paint manufacturing firms in Rivers State depends on supply network design decisions. The study thus recommends that paint manufacturing firms in Rivers State that seek improved service quality should pay attention to supply network design decisions such as mode of transportation, facility location, and vehicle routing.

Keywords: Facility location, service quality, supply network design decisions, transportation mode, vehicle routing

INTRODUCTION

Paint manufacturing firms aspire to meet desired service goals at the lowest possible cost; while keeping pace with market conditions or demand. Firms often make substantial savings in logistics costs and simultaneously improve service levels by (re)designing distribution networks. To achieve this, Akcali, Çetinkaya and Uster (2009) aver that an ideal network has the optimum number, size and location of warehouses to support inventory replenishment activities of retailers within supply chain processes. Supply network design presents managers and scholars in the field of supply chain management with issues, concerns and obstacles given the fact that the concept is relatively new; and the salient issues that define its content, scope and boundaries are still emerging (Amin & Zhang, 2013).

Network design is considered a strategic problem and one of the most critical decisions in supply chain management because of its long term effects on supply chain performance (Bashiri & Hossein, 2012). A crucial aspect of supply chain planning is decisions on the best possible supply network design so that all operations can be performed efficiently. This entails integration of factors such as vehicle routing, transportation modes, facility location with other important functions of the supply chain such as procurement, production,

inventory and distribution, and routing (Otto & Obermaier, 2009). Design decisions are specific decisions that must be made regarding the overall structure and design of the supply chain, including decisions regarding physical network design (capacity positioning, transportation network and facilities), sourcing strategies (component sourcing, spend allocation decisions); social network design (contract flows, information flows, relationship flows, etc.); relationship governance mechanisms (contractual and collaborative governance); and behavioural management strategies (Ozceylan & Turan, 2014).

Firms in Rivers State often fail in their plan to build their facility in strategic positions due to land availability and other factors. Some of these firms adopt road transportation where marine transportation should be preferred (Lead Capital Limited, 2008). These challenges call for a careful design of supply chain network with good understanding of the role of supply network design decisions on business performance. This study therefore, seeks to contribute to extant literature by investigating the connection between supply network design decisions and service quality of paint manufacturing firms in Rivers State.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Supply Network Designs Decision

Ramezani, Kimiagari and Karimi (2014) define supply network designs decision as the configuration of the supply network in which locations and capacities of facilities are determined. The concept of supply network design lies at the very heart of these investment decisions (Badri, Mahdi & Taha, 2013). There are two possible logistics in this regard: forward logistics and reverse logistics. Different firms may have different objectives for the supply network design, but the ultimate objective of supply network design decisions is to increase companies' value through cost minimization (Nwulu, 2019). Supply network design is a rich aspect of supply chain management that goes beyond issues of buyer-supplier relationships or vertical integration to decision of vehicle routing, mode of transportation, and facility location among others.

According to Pishvaee, Rabbani and Torabi (2011), supply network design decision determines the technology, process and manufacturing assets for a company over time, to fulfill customers' demand while remaining competitive. Because most supply chain decisions involve high investment costs and are not easily reversible, network design decision is crucial to long-term success of firms. Due to the long planning horizon and the difficulty to alter a network design on short notice, strategic supply chain decisions face a high exposure to uncertainty while the extent and possible impact of uncertainties is lower for tactical planning and still lower for operations (Badri *et al*., 2013).

Supply network design decision is multidimensional. Chen and Gong (2013) determined facility location, warehouse capacity, transportation mode, material flow, vehicle routing and warehouse layout as dimensions of supply network design decision; while Qiang and Nagurney (2012) identify facility location, capacity of facilities, distribution centre, technology facility and transportation network as dimensions of supply network design decision. Also, Tsao and Lu (2012) and Nagurney (2010) decomposed supply network design decision into capacity of warehouse, mode of transportation, flow of materials, warehouse layout, vehicle routes and location of facility. This study thus adopts facility

location, transportation mode and vehicle routing as dimensions of supply network design decisions.

Facility location

Facility location decisions are decisions made by managers, which are aimed at selecting a location for the settlement of any intended facility of the business concern. Amiri (2006) points out that facility location decisions are usually based on such factors as labor supply condition, raw materials supply condition, distance to market, and several other factors. Decisions on location form an integral part of strategic supply chain planning. Although it might appear that location decisions are one-time problems faced by new firms, existing ones often face more difficult challenge in this regard (Melo, Nickel, Saldanha & Gama, 2007). The location of non-manufacturing operation helps determine how conveniently customers can conduct business with the company. Location of manufacturing and non-manufacturing company operations can have a great impact on operating cost, thereby affecting profit and perhaps the price at which products are offered (Kahraman, Ruan, Chen, & Paulraj, 2011). Analysis of location decision begins with a brief overview of the reasons firms must make location decisions, the nature of these decisions, and a general procedure for developing and evaluating location alternatives (Melo *et al*., 2007).

Facility location concerns the choice of location of one or multiple facilities, in a given geographical space and subject to some constraints, to optimally fulfill predetermined objectives. As a general rule, profit-oriented organizations base their decisions on profit potential, whereas nonprofit organizations strive to achieve a balance between cost and level of consumer service (Albareda-Sambola, Fern´andez, & Laporte, 2007). It would seem to follow that all organizations attempt to identify the best location available. However, this is not necessarily the case. In many instances, no single location may be significantly better than the others. There may be numerous acceptable locations from which to choose, as shown by the wide variety of locations where successful organizations can be found. Furthermore, the number of location that would have to be examined to find the best location may be too large to make an exhaustive search practical (Aksen & Altinkemer, 2008). Consequently, most organizations do not set out with the intention of identifying the one best location; rather, they hope to find a number of acceptable locations from which to choose, and to avoid choosing a location that will create future problems (Plastria, 2001).

Transportation mode

Transportation involves the movement of people, goods and services from point of origin to destination (Tsao & Lu, 2012). Transportation centrally affects the relationship between physical space and society, and changes in transportation affect the organization of human activity. It structures the built environment, spurs growth, as well as facilitates business performance (Ramezani *et al*., 2014). Mode of transport is a term used to distinguish between different ways of transportation or transporting people and products. There are several modes of human and material transportation. However, organizations supply chain network decisions cut across four major areas which are road transportation, maritime transportation, air transportation and pipeline transportation (Ramezani *et al*., 2014; Tsao & Lu, 2012); and since each mode of transportation has a fundamentally different technological solution and require a separate environment, selection of which transportation mode to adopt is crucial a supply network design decision.

Modes of transportation are designed to either carry passenger and freight but most carry **both.** For instance, an automobile has the capacity to carry some freight while a passenger plane has a belly hold that is used for luggage and cargo. Each mode is characterized by a set of technical, operational, and commercial characteristics and these are considered in supply chain network decisions (Ozceylan & Turan, 2014). Technical characteristics relate to attributes such as speed, capacity, and motive technology, while operational characteristics involve the context in which modes operates, including speed limits, safety conditions, or operating hours. The demand for transportation and the ownership of modes are dominant in supply chain networks (Bashiri & Hossein, 2012).

Vehicle routing

Modern transport organizations which run on low operating margins and are governed by extreme market pressures must, as a normal part of business, drive costs down utilizing a range of processes and technologies (Archetti & Speranza, 2012). Presently, the trends to reduce transportation cost among organizations have necessitated the need for efficiency and effectiveness in transportation. Vehicle routing problem has attracted many researchers in the past due to its interesting nature and economic scale (Crama, Rezaei, Savelsbergh, Van, & Woensel, 2018). Battarra, Cordeau and Iori (2014) define vehicle routing as the process of creating the most cost effective transport means through minimization of distance or travel time necessary in order to reach a set of planned stops. Vehicle routing is a crucial process in logistics systems, especially due to high competition and narrowing margins in markets. Routing of goods and services incurs huge costs for vehicle operation, fuel, labor, and maintenance. Dorling, Heinrichs, Messier and Magierowski (2017) define routing in supply chain network, as systems that determine the shortest path between two locations within a road network.

The objective of routing is to minimize total cost of providing service which includes vehicle capital costs, mileage, and personnel costs (Errico, Desaulniers, Gendreau, Rei & Rousseau, 2018). For school bus routing and scheduling, a typical objective is to minimize the total number of student-minutes on the bus (Crama *et al.*, 2018). This criterion highly correlates to safety. For emergency services, such as ambulance, police and fire service, minimizing response time to an incident is of primary importance in routing (Archetti & Speranza, 2012).

Most organizations assure their clients of package delivery within a specific time frame. Thus, an appropriate objective function should consider more than the cash cost of delivering a service. The subjective costs associated with failing to provide adequate service must be considered as well (Fagnant & Kockelman, 2015). Matl, Hartl, and Vidal (2019) argued that vehicle routing problems are often presented as graphical networks. The use of networks to describe these problems has the advantage of allowing decision makers to visualize the problem under consideration and avoid costs associated with failing to provide adequate service to customers (Figliozzi & Tipagornwong, 2017).

Service Quality

The enduring success and survival of any service organization is essentially determined by its ability to deliver quality service to customers. Service quality can be viewed as a perceived judgment, resulting from an evaluation process where customers compare their

expectations with received service. Service quality is the degree of discrepancy between customers' normative expectations and perceptions of service performance. Perceived service quality is then interpreted from the differences in degree and direction between perceptions and expectations. According to Ismail and Yunan (2016), service quality means the ability of a service provider to satisfy customers efficiently. It measures increase in customer satisfaction towards a firm's service and in turn helps the firm to position its service in the minds of customers. By satisfying customers through quality service, firms not only retain their current customers, but also increase their effectiveness and overall performance due to its positive link with profits, increased market share, and customer retention (Ismail & Yunan, 2016).

Earlier studies distinguished quality of service from quality of goods based on the inherent features of service. Hence there is a distinct framework for quality explication and measurement. However, speaking from a general point of view, customers satisfaction gained from customer experience and service quality is a veritable tool for winning customer loyalty and improving business performance (Azman & Norashyikin, 2009). Service quality benefits organizations in a plethora of ways. While some service organizations adopt service quality in building brand image and positioning, some implement it to ensure customer satisfaction, high revenues, increased customer retention and purchase behaviour (Al-Borie & Damanhouri, 2013) all of which ultimately increases market share and general business performance. Any act that predicts variety, quality, dependability and timely delivery of service can be attributed to service quality and leads to business performance (Azman & Norashyikin, 2009).

Supply Network Design Decisions and Service Quality

Supply network design decisions are pivotal to business performance. This is because they easily relates to several market, customer and financial outcomes that signal performance. Firms have thus approached network design decisions with studied diligence. Also, prior studies have hinted a positive connection between network design decisions different outcomes, including service quality. Chen and Gong (2013) studied supply network design and performance; and observed that there is strong significant and positive relationship between supply network and performance of transportation firms. Similarly, Nagurney (2010) investigated effect of optimal supply network design on total cost minimization and demand satisfaction in the Kenyan transport system; and that a significant and positive relationship exists between the variables. Also, Tsao and Lu (2012) examined the effect of supply network design on transportation cost and found a significant and positive relationship exists between supply network design and transportation.

Bhatnagar and Sohal (2005) investigated the impact of facility location on supply chain competitiveness. The study found that location factors significantly impact supply chain competitiveness and manufacturing practices. Similarly, Avittathur, Shah and Gupta (2005) examined distribution centre location modeling for differential sales structure; and found a strong positive relationship between distribution centre locations modeling for differential sales structure. Amiri (2006) likewise, studied distribution network design and supply chain system efficient; and found that there is a statistically strong and positive relationship between facility location and efficient solution procedure in a supply chain system. Aksen and Altinkemer (2008) examined facility location and optimal performance; and revealed

that good location decisions reduces over storage and optimizes performance; while Aardal, Labb, Leung and Queyrane (2006) studied the impact of changing configuration of the distribution network in order to improve financial performance without reducing customer service. The study found that sighting facility in good locations aids effective distribution network and leads to improved financial performance.

The forgoing evidence of positive relationship between supply network design decisions and different aspects of business performance suggests that supply network design decisions will equally relate to service quality, since service quality as also an aspect of business performance. However, for the purpose of statistical analysis and interpretation, the following hypotheses are formulated:

Ho_1: There is no significant relationship between facility location and service quality of paint manufacturing firms in Rivers State.

Ho_2: There is no significant relationship between transportation mode and service quality of paint manufacturing firms in Rivers State.

Ho_3: There is no significant relationship between vehicle routing and service quality of paint manufacturing firms in Rivers State.

METHODOLOGY

The purpose of this study was to examine the link between supply network design decisions and service quality of paint manufacturing firms. The study adopted a correlational research design. The population of the study comprised 18 registered paint manufacturing firms operating in Rivers state which are listed in the Rivers State Yellow Pages (2013/2014). The study took a census because the population is small. However, the study surveyed 72 management level staff of the firms (procurement, logistics, warehouse, and marketing) on a sample frame of 4 respondents from each firms. The final analysis of the study was based on data collected from 49 respondents. The study utilized structured questionnaire to collect primary data from. The instrument was validated via a jury, consisting of academic and industry experts; while its reliability was confirmed through the Cronbach's alpha test with a threshold of 0.70. The Pearson Product Moment Correlation served as the test statistic to assess the linear relationship between the dimensions of supply network design decisions and service quality. All statistical analyses were conducted, relying on the Statistical Packages for Social Sciences (SPSS) version 23.0.

Table 1: Reliability coefficients of proxies of supply network design decisions and service quality

S/No	Variables	No. of items	No. of cases	Cronbach's Alpha
1.	Facility location	5	49	0.849
4.	Transportation mode	6	49	0.714
5.	Vehicle routing	5	49	0.907
6.	Service quality	8	49	0.811

Source: SPSS output of data analysis on supply network design decisions and service quality (2021).

RESULTS AND INTERPRETATION

Table 2: Relationship between Facility Location and Service Quality

		Facility Location	Service Quality
Facility Location	Pearson Correlation	1	.413**
	Sig. (2-tailed)		.003
	N	49	49
Service Quality	Pearson Correlation	.413**	1
	Sig. (2-tailed)	.003	
	N	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS output of data analysis on supply network design decisions and service quality (2021).

Table 2 displays a P(r) of 0.413** on link between facility location and service quality. The value indicates a moderate positive relationship between the variables. The test produced a probability value (0.000) that is less than the critical value (0.05). This shows that the relationship between facility location and service quality is statistically significant. This further implies that facility location contributes to service quality of paint manufacturing firms in Rivers State. Based on this, the null hypothesis was rejected.

Table 3: Relationship between Transportation Mode and Service Quality

		Transportation Mode	Service Quality
Transportation Mode	Pearson Correlation	1	.890**
	Sig. (2-tailed)		.000
	N	49	49
Service Quality	Pearson Correlation	.890**	1
	Sig. (2-tailed)	.000	
	N	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS output of data analysis on supply network design decisions and service quality (2021).

Table 3 shows a P(r) of 0.890** between transportation mode and service quality. This value indicates a very strong positive relationship between transportation mode and service quality. The probability value (0.000) is less than the critical value (0.05); suggesting that the connection between the variables is statistically significant. This implies that transportation mode contributes to the manifestation of service quality of paint manufacturing firms in Rivers State. The study thus rejects the null hypothesis in favour of the alternate.

Table 4: Relationship between Vehicle Routing and Service Quality

		Vehicle Routing	Service Quality
Vehicle Routing	Pearson Correlation	1	.684**
	Sig. (2-tailed)		.000
	N	49	49
Service Quality	Pearson Correlation	.684**	1
	Sig. (2-tailed)	.000	
	N	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS output of data analysis on supply network design decisions and service quality (2021).

Table 4 shows a correlation coefficient of 0.684** on association between vehicle routing and service quality. This value indicates a strong positive relationship between the variables. The probability value (0.000) produced by the test, and which is less than the critical value (0.05) shows that the relationship between vehicle routing and service quality is statistically significant. This further implies that vehicle routing is strongly associated with service quality of paint manufacturing firms in Rivers State. The study thus rejects the null hypothesis which states that there is no significant relationship between vehicle routing and service quality of paint manufacturing firms.

DISCUSSION OF FINDINGS

This study examined the connection between supply network design decisions and service quality. The empirical analyses revealed that supply network design decisions have positive and statistically significant association with service quality. This is demonstrated in the coefficient values of 0.413** between facility location and service quality; 0.890** between transportation mode and service quality; and 0.684** between vehicle routing and service quality. The probability value of the associations is 0.000; which is less than the critical value of 0.005. The results show that the strongest link is between transportation mode and service quality. The results of the study converge with the findings of Boudoin, Morel and Gardat (2014) that supply network design decisions relates strongly to urban logistics effectiveness.

The results also validate the findings of Luo, Qin, Che and Lim (2015) supply network design decisions like vehicle routing impact service delivery consistency. Similarly, the current findings cohere with that Qiu, Qiao and Pardalos (2019) who revealed that vehicle routing impacts optimal production, replenishment, delivery and inventory management. The findings further confirm the position that supply network design decisions are pivotal to business performance; because they easily relates to market, customer and financial outcomes that signal performance (Aksen & Altinkemer, 2008; Aardal, *et al*., 2006).

In addition, the current findings support the findings of Chen and Gong (2013) that there is strong significant and positive relationship between supply network design and performance of transportation firm; and that of Nagurney (2010) that optimal supply network design impacts total cost minimization and demand satisfaction. The finding of Bhatnagar and Sohal (2005) that location factors significantly impact supply chain competitiveness is supported by the findings of this study. The findings also support the observation of Amiri (2006) that distribution network design and facility location positively relates to efficient

solution procedure in a supply chain system; and that of Aksen and Altinkemer (2008) that facility location reduces over storage and optimizes performance.

CONCLUSION AND RECOMMENDATIONS

Faster technological advances, shorter product life cycle and intense global competition are the realities of today's business environment. These force firms to actively acquire new ways to achieve competitiveness. Sustainable competitiveness however, stems mostly from customer equity, which is itself a product of customer satisfaction. Literature is replete with evidence that service quality is a strong driver of customer satisfaction. This study examined the relationship between supply network design decisions and service quality of paint manufacturing firms in Rivers State. The study found that supply network design decisions (facility location, transportation mode and vehicle routing) have positive and statistically significant correlation with service quality.

In view of the results of the empirical analyses and the discussion of findings that followed, the study concluded that supply network design decisions has positive connection with service quality of paint manufacturing firms in Rivers State, through facility location, transportation mode and vehicle routing. The study thus recommends that paint manufacturing firms in Rivers State that seek improved service quality should pay attention to supply network design decisions such as facility location, transportation mode and vehicle routing; as these are found to inform service quality for paint manufacturing firms in the new normal.

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