Supply Chain Disruption in Nigeria Oil and Gas Sector: Some Mitigation Strategies

[1]Nsikan E. John, [2]Ekeins-Wilson T. Margaret, [2]Tarela O. Anyandike, [2]Maria M. Ortencia

[1]Department of Business Management University of Uyo- Nigeria
[2]Faculty of Management Science, Niger Delta University, Bayelsa- Nigeria
Corresponding Author: Nsikiboy5000@yahoo.com

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Abstract- Understanding the internal drivers of petroleum supply chain disruptions could provide a clue to finding lasting solution to the perennial incidence of petroleum product shortages in Nigeria. This study takes another look at petroleum supply chain disruption in Nigeria oil and gas industry by identifying the drivers of disruption and determining mitigation strategies. The study adopted survey method to randomly draw 284 supply chain executives from 38 oil and gas marketing and logistics firms in Nigeria downstream petroleum industry. Data for the study was gathered through structured questionnaire and analysed with descriptive statistics. Results show the top five drivers/causes of supply chain disruption relates to: poor quality of supply chain information, inaccurate product demand forecast, third party logistics outsourcing firms, inadequacy of critical storage infrastructure and components, and poor visibility of inventory position. From the study, major strategies for handling disruption challenges in the downstream petroleum supply chain includes: flexible supply chain, collaborative outsourcing, efficient management of petroleum products inventory, and supply chain relationship coordination. These findings suggest the need for Nigerian National Petroleum Cooperation (NNPC) to advance its supply chain management practices and possibly hands off the refining of petroleum products to private firms.

Index Terms- Supply chain disruption, Mitigation, Downstream petroleum supply chain, Supply chain risks, Inventory visibility

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I. INTRODUCTION

Over the last 10 years, the management of supply chain has become increasingly complex as managers devote attention to address issues arising from globalization, advances in information technology, outsourcing, diversified sourcing, and the lean and green supply chain demand. While the performance effect of these initiatives have received incredible research interest and commendation, they also tend to increase supply chain propensity to disruptions (Christopher and Lee, 2004). A major disruption in any commodity supply chain can have significant dwindling effect on profit, production level, company reputation, shareholder value, and relationship with customers, and may even lead to company closure (Afiqah, Musa, Suraya, and Norhidayah, 2014). The effect of major disruption in the oil and gas industry could ripple through all sectors of the economy that depends on oil for fuel energy and may have a devastating effect on national income. All firms face disruption tendencies in their supply chain, though the magnitude of effect could be alarming for smaller firms than larger ones. Smaller firms tend not to quickly recover from supply chain tension because they lack the internal and adaptive capability, flexibility and redundancy (Simba, Niemann, Kotzé, & Agigi, 2017) to remain resilience (Azadi Jafarian, Saen, & Mkirhedayatian, 2015) and counter supply chain risk as they unfold. Most small size supply chains tend to break down during major disruptions and many of them hardly recover afterwards. For some firms, it may take more than two years to return to pre-disruption performance level. A case in point was the fire disaster in 2013 that cripples the entire operation of Sunflag Textile Manufacturing Company in Lagos, Nigeria for close to three years. As Hendricks & Singhal (2005) rightly noted, regardless of the cause of disruption, the nature of the firm, or when the disruption occur – a disruption has serious devastating effect on firm's economy – profitability performance, shareholder value, and stock price volatility (Hendricks & Singhal 2005).

Some supply chain vulnerability has been due to major one-time occurrence arising from natural hazards, terrorism, and political instability. Example include the US September 11, 2001, oil pipeline explosion perpetrated by militant and insurgent groups in Nigeria Niger Delta, Oil workers 'union strike in 2016, major fire disaster engulfing oil tankers, tank farms and gas depots, the west-coast port strike in 2002, the 2003 northeast blackout, and other acts of nature. However, many other supply chain disruptions particularly in Nigerian downstream petroleum industry could be attributed to inefficient management of the internal processes as well as external networks of petroleum sector supply chain (Akanle, Adebayo & Adetayo, 2014). In the context of this study, petroleum supply chain could be thought of as virtual network of oil and gas service dependent firms, people, technology, activities, information, and financial resources that are involved, through upstream and downstream linkages in creating value by making petroleum products and associated services available to the last-mile user in a cost effective manner.

In comparison with other industries, the petroleum industry supply chain is highly inflexible and complex. Inflexibility stems from production capacity of crude oil suppliers, long transportation lead times, and the limitations of modes of transportation (Hussain *et al*., 2006). The complexity of petroleum

supply chain arises as a result of the numerous infrastructures and global outsourcing organisations operating in the industry (Kazemi, Szmerekovsky, 2015). Morton, (2003) notes that inflexibility and complexity factors make matching demand and supply of petroleum products an uphill task thus increasing the risk of disruptions. Petroleum supply chain process commences with the extraction of crude oil and ends with the delivery of refined petroleum products to consumers. Due to its complexity, any interruption within the chain is capable of undermining the process, causing delay and disruption in the entire system of petroleum products supply (Paul, Sarker & Essam, 2017). By disruption, we imply the accidental and discrete events that significantly impair the activeness and efficiency of any member of the supply chain network for an unplanned period of time (Snyder *et al*, 2014; Chopra & Sodhi 2004), and brings substantial negative consequences to the system (Tang and Musa 2011).

Nigeria is the largest producer of oil in Africa and the petroleum industry supply chain consists of the upstream sector, the midstream sector, and the downstream sector (Aminu & Olawore, 2014; NNPC, 2016). The upstream industry consist mostly of maritime firms charged with exploration, exploitation, and production of crude oil. The midstream supply chain organizations are responsible for refining and storage of petroleum products in tank farms and depots. The downstream supply chain's activities involve marketing, distribution, and transportation of refined petroleum products from the refineries or import jetties to retail outlets to be dispensed to the customers (NNPC, 2016; Osuala, 2013). This study is focus on Nigeria's downstream petroleum supply chain. In the downstream supply chain echelon, there is a complex web of petroleum service providers and logistics firms which rely on physical infrastructures and information network to perform their functions (Fernandes *et al*. 2013). The complexity implies that each activity center and supply chain partners within the entire downstream oil service chain is a potential driver of disruption that should be carefully identified, monitored and moderated.

According to Simba *et al*, (2017) drivers are the sources from which supply chain disruptions occur. The literature delineates several sources of disruptions in petroleum supply chain including: third party logistics (3PL) outsourcing firms- A recent study by Amor & Ghorbel (2018) reveals that Nigeria tops the lists of countries that outsource their oil production and supply process; thereby increasing her vulnerability to disruption risks. The internal operations, external environmental factors and some elements within the petroleum supply chain increase disruption (Olsen, Haugland, Karlsen, & Husoy, 2005; Kim & Chavas, 2003). Natural events, political crisis and global financial crises are examples of external environmental drivers of supply chain disruption. Internal operations, firm's capabilities, information quality and supply chain process visibility (Williams, Ponder & Autry, 2009) are potential sources of petroleum supply chain management pressure. Operational risk refers to the disruptions engendered by problems within the organizational boundaries of a firm that affect its ability to produce and supply goods/services (Hussain, Assavapokee & Khumawala, 2006; Tuncel & Alpan, 2010; Samvedi *et al*., 2013**).** Drivers within the supply chain include globalization, long lead-times, low product shelf life, increased outsourcing, and the rising call for agile, lean and green supply chain management (Thun & Hoenig 2011; Kleindorfer &Van wassenhove 2004). Knowledge of these drivers can serve as guidelines for managers to assess the extent of their supply chain vulnerability. Managers are challenged to device strategies or implement policies that can effectively and efficiently mitigates supply chain disruptions either by reducing the probability of occurrence, or limiting its impact on the supply process, or eliminating the risks altogether.

A vast approach to mitigating supply chain disruptions abound in the literature. Tang (2006) argued that mitigation measures could incorporate either long-term planning or short-term planning that generates mitigation tactics and contingency plans. Inalegwu & Raul, (2014) suggests: increase in capacity, inventory, responsiveness, flexibility, aggregating demand, and keeping multiple and diversified supplier base. Tomlin, (2006) site examples of mitigation tactics to include contingent sourcing, expediting orders, rerouting deliveries and lateral and vertical emergency transshipments. Sheffi (2005) and Simona, (2016) suggests dual sourcing, increased product, volume, routing and delivery flexibility and information visibility and management. In Singhal, Agarwal & Mittal's (2011) submission, having flexible supply base not only enables a firm to handle regular demand–supply variances, but helps to build organizational resilience when major disruption occurs. Lee &Tang (1996) advocates in- house production of certain goods when facing potential supply disruptions while other products are outsourced. Nsikan, Ekeins, Tarela, & Affiah (2018) reported that ensuring forecast accuracy through proper quantification, building trust in supplier collaboration, and investing in supply chain visibility/transparency reduces the probability of disruptions. Inalegwu & Raul, (2014) submits that investment in appropriate information technology particularly radio frequency identification tags (RFID) is known to reduce the chances of disruptions by increasing inventory visibility, tracking shipment in transit and tracing inventory and orders across the entire system of oil supply chain (Inalegwu & Raul, 2014; Nsikan, John and Tommy,2014). Access to real time and transparent information reduces the bullwhip effect and provide accurate demand and supply information necessary to mitigate the disparities in product demand and supply.

A prominent but unfortunate feature of the Nigerian petroleum industry is frequent petroleum product shortages. Nigeria has frequently experienced disruptions in the supply of petroleum products over the years. This cripples business activities, leading to loss of revenue and underdevelopment since most business enterprise depends on petroleum products for survival (Aminu and Olawore, 2014; Adelabu, 2012; Osuala, 2013). There are practical evidences which may suggest the presence of some mechanisms to mitigate disruptions in Nigeria petroleum industry supply chain. However, the effectiveness of these mechanisms appear doubtful given the numerous shortages of refined petroleum products, product adulteration, and the attendant socio-economic consequences. There is remarkable research interest in supply chain process disruption in the oil and gas industry. However, the frequent incidence of petroleum product shortages in Nigeria probably exemplifies the insufficient empirical insight into the internal drivers of petroleum supply chain disruption and their mitigation strategies.

This study is therefore aimed at exploring the Nigeria downstream oil and gas industry with a twofold objectives: First, identifying the sources of supply chain system disruptions and second, determining the strategies to mitigate petroleum supply chain disruptions in Nigeria. With these specific objectives, we hope to provide a way for oil and gas industry managers to appreciate how their actions, behaviors and internal work processes promote products supply disruptions. This is likely to inspire the adoption of current and future mitigation practices in the entire petroleum supply chains.

II. Methodology

2.1 Design

This study was quantitative in approach and adopt survey methodology due to its economy, rapid data collection and ability to understand the characteristics of the population under study (Creswell & Clark, 2010; Hair, Anderson, Tatham, & Black, 2009). The quantitative approach entails the collection of primary data through a structured questionnaire, and analyzing data numerically.

2.2 Sample

A random sample of 423 supply chain managers constituted the eligible participants. They were drawn from 38 indigenous and multinational oil prospecting, distribution and service firms, operating within the downstream petroleum sector and located within the Niger Delta region. Sample was so selected because of the largest concentration of oil and gas companies in the Niger Delta region. This ensures representativeness of the entire country. These set of sample participants were also selected because: they were all operators of oil and gas supply chain in the downstream petroleum sector, their supply chain activities were somewhat homogenous and were much likely to face similar petroleum supply chain disruption issues in the industry.

2.3 Instrument of Data Collection

Primary data for the study was collected through the structured questionnaire which was developed by the authors and tested (pilot study) for content validity and reliability. Inputs were taken from extensive review of relevant supply chain disruption literature and pre-survey discussions with oil and gas supply chain practitioners to construct the instrument. It consisted of 5-points Likert type scale statements designed to prompt responses on the internal drivers of supply chain disruptions and the strategies for their mitigation. Among the 423 eligible respondents, 139 were either not able to complete their questionnaire on schedule or were not accurate in answering the questions as required. Thus, the remaining 284 copies of the questionnaire were found useful for data analysis and 67.1% response rate was achieved.

2.4 Techniques of Data Analysis

Data collected from survey were subjected to descriptive analysis and interpretation. To this extent, proportion, mean score and standard deviation were used to describe and summarize the behavior of data in the distribution and to make decision. The mean score was derived by dividing the sum of the scale by 5 to get a mean score of 3.00. Mean scores $\geq$ 3.00 implies that such variable was an important driver of disruption. In other words, a variable with mean score 3.00 and above constitute a high risk disruption factor. On the other hand, a mean score less than 3.00 was considered an index of non-agreement, such variable was not considered very important in causing petroleum sector supply chain disruption.

III. Results and Discussion

3.1. Drivers of petroleum supply chain disruption

In today's supply chain, many sources of petroleum sector supply chain disruption can be found. It is crucial to understand the sources of disruption in order to develop solutions to either reduce or prevent their occurrence in future. Results of data analysis in this section depicts the various internal sources perceived by respondents as causing supply chain disruption in the study area. Data on Table 1 outlays respondent's ranking of drivers of disruption in Nigerian downstream petroleum industry.

As can be seen from Table 1, out of the 13 drivers suggested, respondents ranked nine as most frequent sources of disruption. The top five drivers/causes relate to: poor quality of supply chain information (Mean= 3.79, SD= 0.97), inaccurate product demand forecast (mean= 3.75, SD= 1.04), third party logistics outsourcing firms (Mean= 3, 75, SD= 1.03), inadequate storage infrastructure (Mean= 3.74, SD= 1.06), poor visibility of inventory position (Mean= 3.7, SD= 0.99). On the other hand, single sourcing/rigid supplier base, poor capability of SCM personnel, inability to track shipment, and non-transparent dealings with suppliers were the bottom four drivers of petroleum supply chain disruption in the context of this study. From the view of the entire sample, it is possible to infer that the issues that create tension in the downstream petroleum supply chain network are operational in nature; and could be avoided/handled given availability of appropriate storage and logistics infrastructure, increased investment in SC information technology, proper coordination of key suppliers' activities, and sharing quality information amongst supply chain partners. The findings appears consistent with Amor & Ghorbel (2018), Williams, Ponder and Autry, (2009), Hussain *et al*., (2006), Kleindorfer & Van Wassenhove (2004).

Table 1: Drivers of petroleum supply chain disruption (N=284)

Sources of Disruption	*VF*	*F*	*SF*	*NVF*	*NF*	*Mean Score*	*SD*	*Rank*
Inadequate storage infrastructure.	66(23.2)	116(40.8)	73(25.7)	21(7.4)	8(2.8)	3.74*	0.99	4
Inaccurate demand forecasting.	72(25.4)	115(40.5)	65(22.9)	20(7.0)	12(4.2)	3.75*	1.04	2
Inability to track shipment.	37(13.0)	70(24.6)	53(18.7)	58(20.4)	66(23.2)	2.84	1.37	12
Logistics outsourcing	83(29.2)	101(35.6)	61(21.5)	23(3.1)	16(5.6)	3.75*	1.13	3
Poor quality of SC information.	65(22.9)	127(44.7)	69(24.3)	12(4.2)	11(3.9)	3.79*	0.97	1
Non-flexible procurement.	50(17.6)	97(34.2)	77(27.1)	50(17.6)	10(3.5)	3.45*	1.08	8
Poor visibility of inventory position.	67(23.6)	100(35.2)	89(31.3)	20(7.0)	8(2.8)	3.70*	0.99	5
Over dependence on importation	35(12.3)	111(39.1)	46(16.2)	34(12.0)	58(20.4)	3.11*	1.35	9
Poor capability of SCM personnel	35(12.3)	86(30.3)	50(17.6)	49(17.3)	64(22.5)	2.93	1.37	11
Poor form of transport infrastructure	82(28.9)	93(32.7)	71(25.0)	27(9.5)	11(3.9)	3.73*	1.09	6
Low investment in SCM technology	75(26.4)	87(30.6)	82(28.9)	33(11.6)	7(2.5)	3.67*	1.06	7
Single sourcing/rigid supplier base	26(9.2)	83(29.2)	82(28.9)	36(12.7)	57(20.1)	2.95	1.26	10
Fairness in dealing with suppliers	25(8.8)	81(28.5)	75(26.4)	45(15.8)	58(20.4)	2.89	1.26	13

** Significant; SD = Standard Deviation; VF = Very Frequent; F = Frequent; NVF = Not Very Frequent; NF = Not Frequent; SF = Somewhat Frequent*

3.2 Strategies for mitigating petroleum supply chain disruption

A number of strategies might help to mitigate petroleum supply chain disruption. We asked managers to indicate the strategies most often resorted to when confronted with supply disruptions challenges. For purpose of clarity and analysis, their responses were further categorized into four streams of mitigation strategies namely: Flexible supply chain system, logistics outsourcing, efficient inventory management, and supplier relationship management. Table 2 summarizes the extent to which firms apply an array of practices to combat their supply chains disruption challenges.

In terms of flexibility, the literature suggests that maintaining flexible supply chain processes could provide reliable option in curbing oil supply chain disruption risks. Therefore, it is not out of place to find respondents scoring high in all flexible supply chain dimensions except delivery flexibility. As can be observed in Table 2, delivery flexibility had the lowest score (Mean=2.32, SD= 1.06) and was therefore rated poorly amongst oil sector supply chain managers. Thus, while managers often resort to making their supply chain activities flexible in terms of product volume, contract and tendering, shipment routing, and procurement techniques, they were reluctant to adopt flexible delivery systems in complex, risky and difficult petroleum supply situations. In all cases, however, sample appear to depend greatly on volume flexibility (Mean = 4.62, SD= 1.21) to combat supply chain vulnerability.

Table 2: Mitigation Strategies

Item Description	*Number of agreed response*	*Mean*	*SD*
Flexible supply chain system			
Delivery flexibility	178	2.32	1.06
Volume flexibility	239	4.64	1.21
Flexible contract and tendering	206	3.35	0.79
Shipment route flexibility	215	3.41	0.86
Procurement flexibility	236	3.49	0.82
Logistics outsourcing			
Storage and distribution outsourcing	224	4.34	1.06
Infrastructure management outsourcing	219	3.12	0.81
Supply chain personnel outsourcing	251	4.03	1.38
Efficient inventory management			
Build buffer capabilities	188	3.20	1.16
Monitor inventory level	231	2.45	1.02
Invest in inventory system IT infrastructure (eg RFID)	232	2.67	1.21
Shipment visibility (Track &Trace)	235	2.36	1.08
Supplier relationship management			
Multiple & diversified supplier base	283	4.61	1.24
Collaborate intelligently	227	2.10	1.07
Evaluate performance capabilities	231	1.99	0.97
Vendor development	208	2.79	1.20

Proper outsourcing practice was also considered a way of handling issues in the petroleum supply chain network. Respondents made case for participating in outsourcing agreement in three significant areas, namely: storage and distribution, (Mean = 4.34, SD= 1.06), management of oil infrastructure (Mean = 3.12, SD= 0.81), and personnel outsourcing (Mean = 4.03, SD= 1.38). All three outsourcing activities were significantly relied upon for mitigation by oil service managers. The findings in this section lends credence to prior study by Amor and Ghorbel (2018), Olson & Wu (2011), and Kohler & Thomas (2010). Similarly, efficient management of inventory management is considered in many literature as important means of supply chain risk mitigation. Though sample seems to be aware of the importance of efficient inventory management; given the number of agreed respondents for each dimension, they actually score low in using most of the strategies for disruption mitigation purposes. Except by building more buffer capacities (Mean = 3.20, SD= 1.16) for holding safety stock because of flexible volume, all other inventory management techniques (inventory monitoring, RFID, tracking and tracing shipment, regular physical stock review and audit) seem not to be widespread amongst respondents. This finding has serious managerial implications to the management of petroleum supply chain in the Nigerian downstream petroleum industry. Proper management of oil and gas stock using DFIR technology in particularly has been fund to be highly useful in dealing with product supply disruption challenges (see Inalegwu and Raul, 2014; Nsikan *et al*, 2014; Emad & Adil, 2013).

One other means of managing supply chain disruptions found in the literature is supplier relationship management (SRM). This entails proper coordination of supplier's activities, maintaining multiple and diversified supplier base, intelligent collaboration, performance evaluation, and vendor development. As can be observed in Table 2, most of the SRM framework are not frequently relied upon by sample managers except for the case of keeping multiple supplier base (Mean = 4.61, SD= 1.24). With reference to the supplier relationship management, the current finding seems consistent with Singhal *et al*, (2011) which reported that having flexible, diversified and multi-supply base enables firms to handle regular demand–supply variances and helps build resilience.

IV. Conclusion

Maintaining disruption-free supply of petroleum products is an objective desired by all oil and gas firms in the downstream petroleum supply chain. Though this comes with huge operational costs, oil companies often struggles with the challenges of increased costs of service delivery as they try to keep up with expectation from end users. Therefore, petroleum supply chain must be efficient and integrated to remain competitive and live up to its social obligation. An important means of achieving uninterrupted flow of petroleum products at minimal cost and at the right time to last-mile users is supply chain disruption management. It is possible to make three important conclusion in this study: First, the downstream petroleum supply chain could have improved operations in

terms of timely supply, quality delivery, and reduced operating costs if operators understand the causes/ sources/ or divers of supply chain system disruption, and strategically select appropriate strategies of mitigation. Second, the exchange of accurate and timely information regarding inventory position and costs, incoming orders, and demand data along the supply chain network is capable of enhancing visibility in the entire network. Third, the mitigation of supply chain disruptions in the oil and gas sector of Nigeria and probably in other developing nations can be facilitated by strategies that centers on flexible supply chain processes, collaborative outsourcing, efficient management of petroleum products inventory, and intelligent supply chain relationship coordination and management.

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