

Factors affecting the performance of a manufacturing supply chain, and the organization

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Abstract—Due to constant failure in delivering the products to customers on time the defence manufacturing organization introduced the supply chain phenomenon into its operations in an attempt to improve its performance (on-time delivery). This research aims to identify if supply chain performance is affected mainly by social or technical factors and also outline which of these factors have the highest effect on the performance of supply chain. The importance of this research is that it will determine if the performance of supply chain is affected by technical or social factors and also how the organization is affected by these factors. This research employed a case study and made use of both qualitative and quantitative data to allow for data triangulation in order to minimize biasness and increase the credibility of the results. The findings indicate that supply chain performance is affected by both social factors and technical factors, however the impact of these factors on both supply chain and the organization is different. In summary, this research will provide insight to the factors that affect the performance of supply chain and accordingly provide methods to minimize or eliminate these factors and therefore reducing their effect on supply chain and the organization.

Keywords—Supply chain, collaboration, integration, information sharing

I. INTRODUCTION

The process from purchasing of raw material to the ultimate consumption of the finished product linking across suppliers or end user companies is known as supply chain [1]. For this research supply chain is defined as a system organization consisting of people, activities, information, and resources involved in delivering a product or service to a customer. In April 2015, a defence manufacturing organization in its efforts to try and combat the challenges faced by the organization introduced the supply chain philosophy to its operations. The challenges faced by the organization included cost of poor-quality, and failing to meet customer satisfaction, i.e. (on-time delivery). Failing to meet customer requirements in terms of delivery had a negative impact on the organization.

Upon formation, supply chain was given a strategic objective derived from the organization's balance score card (BSC) to obtain and maintain a delivery and quality performance of 95% respectively. The average delivery performance of the organization between the financial periods of 2014, 2015, and 2016 was 62%, 61%, and 59% respectively. To improve the performance of supply chain it is imperative to have a collaborative supply chain. Companies grow (increase revenue), achieve customer satisfaction, and improve their efficiencies through good relationships between its customers and suppliers. What contributes the most to this success is the effective management of information and material flow [2].

What is already known from literature is that there are 19 factors that affect supply chain performance, however, only 7 of the 19 factors have the highest effect on supply chain performance [2] [4] [6] [7] [15] [17]. It is also indicated in literature that lack of information sharing is the main contributing factor that affects supply chain performance. However, the commitment of top management is still vague and not clearly defined and it is therefore unknown as yet what role management needs to play to ensure that supply chain performance is at its peak. This research will aid supply chain organizations to identify which factors are affecting their performance the most and how best can these factors be improved. The purpose of this research is to identify factors that have the highest effect on the performance of supply chain and the impact that these factors have on supply chain and the organization.

The first section summarizes what literature suggests are the factors that have the highest effect on the performance of supply as well as the impact that these factors have on supply chain and the organization.

II. LITERATURE REVIEW

Supply chain can be structured in different ways depending on who the end customer is in the value chain and also taking into consideration the operating model of the business, i.e. whether the model is a business to customer (B2C) or a business to business (B2B) model. However the definition of supply chain remains similar since the principles and activities are also similar. Figure 1 illustrates one of many ways of how a supply chain function can be configured generally since it is a function of controlling material and information flow starting from receipt of material from external suppliers to dispatching products to customers or end-user [3]. The configuration shown in figure 1 is not a representation of the of the supply chain organization with the defence manufacturing organization.

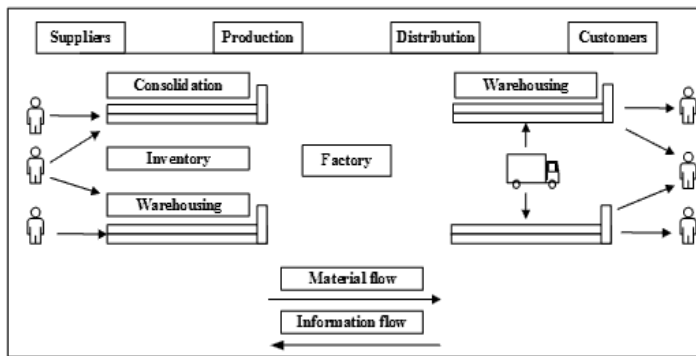


Fig. 1. The scope of supply chain [3]

There are three distinct models that an organization can operate on and this operating model will determine the structure of supply chain. (i) Make-to-order: the manufacturing process only commences once an official order has been received from the customer. (ii) Make-to-stock: manufacturing can commence without an official order or request from a customer but deliveries will only be made on receipt of official order. (iii) Engineer-to-order: in this instant the design process will only commence upon receipt specifications and fund commitment for development work from the customer, and main stream manufacturing will not commence without an official order [4]. The use of engineer to order model has an effect on the performance supply chain. This model puts additional strain on the organizational resources, i.e. both equipment and human resources since resources are shared between main stream production, development and repairs and maintenance [5]. Even though there are organizations that have benefited from the implementation of supply chain, there are other organization that are still faced with challenges. These challenges are brought about by various elements including the operation of the organization [2] [6] [7] [8]. Information sharing has become an integral part in the approach that most organizations have taken to try and maintain their position or improve their competitive advantage in the market. However information sharing within supply chain may encounter a number of challenges and as a result on time delivery of products is affected [9] [10]. On time customer delivery is affected by both

technical and social factors, however, technical factors been highlighted as the highest contributing factors to poor supply chain performance [11]. According to literature the factors tabulated in table 1 are the factors with the highest effect on supply chain performance.

Table 1. Factors affecting the performance of supply chain

Factors	Type of Factor		Type of operating environment		
	T	S	M-to-S	M-to-O	E-to-O
Technological capability [14] [15] [16] [12] [17]	x		x	x	x
Top management commitment [17] [18] [19]		x	x	x	x
Co-operation and support from supply partners [2] [3] [24] [25]	x	x		x	x
Information sharing [2] [10] [13]	x	x	x	x	x
Monitoring supplier performance [6] [7] [8]	x			x	x
Application of quality management principles [14] [15] [16] [17]	x				
Employee involvement / incentive (appraisal and reward) [19] [20] [21]		x	x	x	x

T = Technical; S = Social; M-to-S = Make-to-Stock; M-to-O; Make-to-Order; E-to-O = Engineer-to-Order

Lack of information sharing affects supply chain performance determinants such as demand forecasting, lead-times, pricing and product quality. Lack of information sharing also impacts on the ability of supply chain to be agile [11] [12].

Another factor that affects the performance of supply chain is the technological capability of the infrastructure. If the technological systems employed by the organization are not aligned with the operational processes such as online customer order tracking, online purchasing, web-based Electronic Data Interchange (EDI), and vendor management inventory (VMI) cannot be applied in order to improve supply chain processes [8] [13] [14]. The impact that the use of technology has on the performance of supply chain is not a simple research to conduct since there are multiple variables between financial and non-financial performance measures. It is also imperative to note that the implementation of a new system can have a negative effect on the performance. However old technology that is obsolete can be rather difficult to use and can cause continuous delays which will also affect the performance of supply chain and the organization [15].

Top management commitment is another factor that can go a long way in assisting the organization to improve its performance. Top management commitment should go beyond improving supply chain performance and also start looking at the sustainability of the organization as a whole [16] [17]. The level of top management commitment to supply chain is

dependent on whether the organization operates on a business-to-business or business-to-customer model [17].

Over and above information sharing, technological capability, and top management commitment, employee empowerment and involvement is another factor that affects the performance of supply chain. Employee satisfaction and a conducive working environment are some of the elements that can affect the performance of supply chain [18]. If the environment is not conducive for employees it then leads to lack of interest, poor decision making, and possibly high absenteeism which affects productivity. This has a direct impact on the performance of supply chain and affects customer deliveries as well as the profits of the organization [18]. Figure 2 shows the elements that have been discussed above which affect the employee productivity.

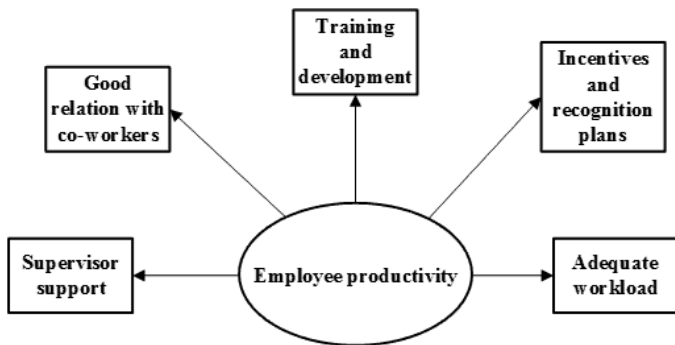


Figure 2. Workplace factors affecting employee productivity [17]

A conducive working environment is not only limited to the physical space that employees perform their functions from, it is much more than that. Supervisor support, training and development, growth opportunities, coupled with adequate workload and incentives and recognition also helps to improve the productivity of employees [18] [19] [20].

Poor application of quality management principles is another factor that affects the performance of supply chain. The application of quality management principles, tools, and systems contribute to poor performance of supply chain and has financial impact on the organization [19] [20]. Operational improvement in supply chain and the application of the correct quality principles can help reduce inventory levels, cost of poor quality, cost of warranty repairs, and improve the quality of the final product [21][22].

Both technical and social factors have an effect on the performance of supply chain. These factors affect the organization both financially and non-financially. It is also critical to note that depending on how these factors are addressed they can either regress or progress the performance of supply chain [3] [22] [23]. Another aspect of the impact that these factors have is that if information is not shared then collaboration cannot happen and new development work might take longer, the design costs can increase rapidly, and supply chain can miss out on technological improvements [24]. The

impact to supply chain is not only linked to monetary value but there is also a non-financial component to it which includes brand reputation, loss of trust, and loss of future potential business [19] [25].

III. METHODOLOGY

This is a case study research (real life problem) that employed the use of mixed methods for data collection. The research only focused on identifying factors that affect the performance of a manufacturing supply chain within the defence manufacturing organization and not any other organization or organization within the same industry. The fundamental reason for using mixed methods for data collection was to enable the researcher to develop further understanding of the research problem. The other benefit of mixed methods is that it allowed for triangulation of data once the analysis was completed. Triangulation allowed for more credible results to be presented and was used to neutralize any form of biasness that might have occurred during data the collection process. The reliability of the primary data was questionable due to the fact that the respondents could have provided information that would not outline the challenges within their specific areas of operation. The researcher had no control on the integrity of secondary data since this data was captured prior to the research being conducted and data was collected for other reasons other than this research.

Two sets of data were collected, that is primary data (face-to-face interviews) and secondary data (system data). Secondary data was drawn from an operational management tool that is used to measure the performance of supply chain and the organization. Secondary data from January 2015 to April 2017 measuring the monthly performance of supply chain and the organization was used for this research. Secondary data was supplemented by primary data that was collected through face-to-face interviews with the use of a questionnaire. Non-probability sampling was the method used to select the sample of respondents to be interviewed for this research within the defence manufacturing organization. This method allowed the researcher to use their own personal judgement, experience, and knowledge of the organization in deciding who will form part of the sample. A total of 30 respondents were interviewed through face-to-to-face interviews. The sample was selected looking at the objectives of the research and also looking at the key areas within the organization that are affected by supply chain and those which have an effect on supply chain. The sample was made up of 8 project managers, 6 test and design engineers, 4 supply chain management team, 6 supply chain operators, 3 sales and marketing managers, 3 quality personnel.

IV. RESULTS

The results presented in this paper covers all analysis done on operational data. This consists of customer on time deliveries, internal deliveries (deliveries from supply chain to internal customers, i.e. project office) and external supplier deliveries. Also included is the analysis of the interview data. Operational data was analyzed looking at the hierarchy ranking of the sub elements that have a direct effect on the performance of supply chain. These sub elements include (i) supply of components from external suppliers, (ii) internal production lead-times, and (iii) shipping of final product to the end-user or customer. The analysis on customer deliveries was done looking at two dates, i.e. contractual date and negotiated date. Table 2 shows the results of the analysis of customer deliveries.

Table 2. Average on-time delivery - Customer

Financial Year	Contractual date performance	Negotiated date performance
2014	41%	64%
2015	42%	64%
2016	26%	54%
Average	36%	61%

Results of analysis indicate that the performance of the organization was better against the negotiated date but very poor against the contractual date. However this is still not in line with the set target of 95% as outlined in the organizational strategy. Table 3 shows the analysis results of internal deliveries, i.e. from supply chain to internal customer. This data looks at the planned production units against the actual produced units.

Table 3. Average on-time delivery - Internal

Financial Year	Total planned quantity	Total delivered quantity	Total backlog quantity	Average on time delivery
2014	1808	921	-887	49%
2015	2331	1224	-1107	52%
2016	904	673	-231	75%
Average	1681	939	-742	59%

Looking at the displayed results there was a steady improvement in the performance of supply chain since its inception, however the average performance is still 59%. The two sets of results indicate that there is a relationship between internal deliveries and customer deliveries. Internal deliveries are dependent on delivery of components from external suppliers. Supplier on time delivery is measured against two dates, i.e. the original purchase order date as well as the negotiated delivery date, the performance of external supplier was found to be at an average of 61% which is also less than the desired 95%.

There are three top contributing factors that affect customer deliveries and these are; (i) Production delays (35%), (ii) Procurement delays (24%), and (iii) contractual disputes (20%). However for this research only the top two factors will be considered as data relating to contractual disputes could not be obtained due to its sensitivity. The two factors have 9 sub elements that affect the performance of supply chain with

production delays having two sub elements and procurement delays having seven sub elements. Table 4 displays results of the top contributing sub element (poor workmanship) that affects production delays, the other sub element (equipment unavailability) cannot be scientifically quantified.

Table 4. Effects of poor workmanship on production

Financial Year	Number of ITF occurrences	Number of items affected	Number of reworked items	Number of scrapped items
2014	6036	1701	1532	169
2015	10055	3412	3305	107
2016	4749	952	919	33
	20840	6065	5756	309

From the results presented in table 4 it can be seen that the total number of items affected by ITF's (inspection test failures) is 6065 and out of that total amount at least 5756 (95%) items were reworked as a result of poor workmanship and 309 (5%) items were scrapped and had to be remanufactured. Table 5 shows the analysis of the top four sub elements and the effect these sub elements have on the on supply chain performance. Between 2014 and 2016 there were 211 occurrences of delays at manufacturer leading to 48% (103585) of the items being affected. Shipping delays occurred at least 142 times and affected 21% (45823) of the items with issuing of permits being the main contributing sub element at 38%. Another contributing factor was delays at goods in coming which occurred a 151 times and lead to 18% (39630) of the items being affected by component shortages with the main contribution being the shortage of stuff to compliment the rate of supplier deliveries. Acceptance of supplier delivery dates by the organization was also a contributing factor and this was mainly due to the lead-times quoted by various suppliers, material availability, and supply of incorrect or incomplete data packs. The main sub element relating to this factor was having single source-suppliers and not having sufficient alternative suppliers.

Table 5. Effects of procurement delays

Sub elements	FY-2014	FY-2015	FY-2016	Number of items affected
Production delays at manufacturing	147	56	8	103585
Shipping delays	99	40	3	45823
Delays at good receiving	146	5	0	39630
Acceptance by organization	330	437	72	28581
	722	583	83	217619

Results of interview data analysis which was done using the attitude measurement ranking (Likert scale of agreement), suggest that information sharing is the top contributing factor that affects the performance of supply chain. Co-operation from supply chain partners and monitoring supplier performance were also ranked high during interviews. Table 6 below displays rating of the factors based on the respondents level of agreement.

Table 6. Respondents level of agreement rating

Factors	Weighted total	Weighted mean	Ranking
Information sharing	46	6.1	1
Co-operation and support from supply chain partners	43	5.7	2
Monitoring supplier performance	39	5.4	3
Application of quality management principles	39	5.2	4
Technological capabilities	28	3.7	5
Employee involvement / Incentive (reward)	21	2.8	6
Top management commitment	26	1.8	7

Furthermore results of interview data analysis indicated an additional factor in the form of organizational culture which also has an impact on the performance of supply chain. Although organizational culture is not one of the listed factors from literature it is evident that within the context of the defence manufacturing organization it is one of the factors that contribute towards poor supply chain performance. According to interview data organizational culture is one of the main contributing factor and has a number of sub elements which have a direct effect on employees. The effect of this is that employees become disengaged, do not show commitment, lack ownership and can possibly lead to the organization having a high staff turnover resulting in loss of valuable skills and knowledge in supply chain and the organization. Respondents provided detail on their level of agreement based on results from literature and also provided data based on their previous experiences.

V. DISCUSSION

The discussion considers the objective of this research to address the two fundamental research questions that were asked. (i) What are the factors that affect the performance of supply chain? (ii) What is the impact of the factors on supply chain and the organization? Results from literature and those from the interviews suggest that not sharing information is the main contributing factor to poor supply chain performance. This is in agreement with the central insinuation of the research which suggested that inadequate information flow within supply chain can affect the performance of supply chain and the organization. Based on the results of the analysis the common pattern that is noted in the results is that technical factors contribute highly to poor supply chain performance and this is evident based on the factor listed in table 1. Factors listed in table 5 which are results of operational data can be linked to four other factors that were drawn from literature (factors listed in table 1) and these factors are co-operation and support from supply chain partners, information sharing, monitoring supplier performance, and application of quality management principles. These are the three factors that contribute highly to the poor performance of supply chain within the defence manufacturing organization. However, outside of the factors listed in literature it is also imperative to highlight the effect of organizational culture on the employees and how that in turn affect the employees productivity which could have a direct impact on supply chain performance. The impact on supply chain has a direct effect on

the performance of the organization and the impact on the organization can be financial and non-financial.

VI. CONCLUSION

This paper provides a summary of the initial findings of literature research towards the factors that affect the performance of a manufacturing supply chain. The research reviewed relevant literature, from which two research questions were developed and a research objective was defined. The paper further provides an overview of the methodology used to identify the factor and the impact of the factors on both supply chain and the organization.

Outside of the literature findings operational data highlighted two major factors that affect the performance of supply chain namely; production delays and procurement delays. Poor workmanship was the main sub-element for production delays, with delays at manufacturer as well as shipping delays being the two main contributing sub elements to procurement delays. Interview results and findings from literature agreed that the main contributing factor to poor supply chain performance was lack of information sharing. Interview data further indicated that organizational culture was also a contributing factor that affects the performance of supply chain within the defence manufacturing organization. The identified factors have both financial and non-financial impact on supply chain and the organization. However the non-financial impacts appears to be of grave concern as it will in future be a contributing factor to the social impact which can come in a form of retrenchments, short working time, or even shutting down the operations of the organization.

The results presented in this paper addresses the research questions and objective of the research and provide a foundation for further research into the cause of sub elements that are linked to some of the factors to determine what the drivers of these elements are and how best can they be dealt with.

VII. REFERENCES

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