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UTILISATION OF FORECASTING TECHNOLOGY FOR IMPROVING CONSTRUCTION LOGISTICS IN NIGERIA

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ABSTRACT

The need to investigate new technology for forecasting purposes in construction logistics is due to the fact that the forecasting ability (modern technology utilisation) of the Nigerian construction sector, in terms of logistics management, is relatively low when compared to manufacturing and retailing industries. This is affecting the performance of the construction sector. Moreover, the current logistics technologies used for forecasting operations in the Nigerian construction industry are relatively inefficient and insufficiently investigated to inspire new logistics technologies for the construction industry. Hence, this article investigated how forecasting logistics technologies could be utilised in manufacturing and retailing industries, in order to improve the forecasting processes of construction logistics. Lagos State and Abuja, the Federal Capital Territory of Nigeria, formed the selected geographical scope of the study, from which five manufacturing; five retailing companies, and five construction projects were purposely selected. A mixed methods research strategy were used. The research instruments included an observation guide (quantitative) and semi-structured interviews (qualitative). The collected quantitative data were analysed, using descriptive analytical tools: frequencies and percentiles. The qualitative data was analysed, using the thematic method. The results revealed that all the observed manufacturing industries (100%) adopted the Enterprise Resource Planning (ERP) technology for forecasting purposes in the following areas: material, demand, product, and production forecast. Of the observed companies in the manufacturing and retailing industries, 80% and 40%, respectively, adopted the Material Requirement Planning (MRP) technology for forecasting purposes. Only 20% (one project) of the observed construction projects adopted the MRP technology for forecasting in the following: 5% for demand forecast (demand control); 6.7% for material forecast (stock control), and 20% for product forecast (product output). It was also revealed that utilisation of the forecasting technology in construction could have the following benefits: proper resource planning; improved production scheduling; reduction in inventory; effective treatment of scheduling problems, and efficiency of the supply-chain system. Results showed that effective utilisation of forecasting technology in the logistics system of the construction industry could lead to full efficiency gains in forecasting logistics of the construction industry. It is recommended that the Nigerian construction industry should leverage on this, in order to create the best ways of handling the forecasting technology to improve the forecasting logistics systems of the construction process.

Keywords: Construction, DM, ERP, IRES, MRP, forecasting, logistics, technology

ABSTRAK

Die behoefte om nuwe tegnologie vir voorspellingsdoeleindes in konstruksielogistiek te ondersoek, is te wyte aan die feit dat die voorspellingsvermoë (moderne tegnologie-gebruik) van die Nigeriese konstruksiesektor, wat logistieke bestuur betref, relatief laag is in vergelyking met die vervaardigings- en kleinhandelbedrywe. Dit beïnvloed die prestasie van die konstruksiesektor. Boonop is die huidige logistieke tegnologieë wat gebruik word vir voorspellingsbedrywighede in die Nigeriese konstruksiebedryf relatief ondoeltreffend en word onvoldoende ondersoek om nuwe logistieke tegnologieë vir die konstruksiebedryf te inspireer. Daarom het hierdie artikel ondersoek hoe die voorspelling van logistieke tegnologieë in die vervaardigings- en kleinhandelbedrywe gebruik kan word om die voorspellingsprosesse van konstruksielogistiek te verbeter. Lagos-staat en Abuja, die Federale hoofstadgebied van Nigeria, vorm die geselekteerde geografiese omvang van die studie, waaruit vyf vervaardiging; vyf kleinhandelondernemings, en vyf bouprojekte is doelbewus gekies. ‘n Gemengde navorsingsmetode is gevolg. Die navorsingsinstrumente het ‘n waarnemingsgids (kwantitatiewe) en semi-gestruktureerde onderhoude (kwalitatief) bevat. Die versamelde kwantitatiewe data is geanaliseer met behulp van beskrywende analitiese instrumente: frekwensies en persentiele. Die kwalitatiewe data is met behulp van die tematiese metode ontleed. Die resultate het aan die lig gebring dat al die waargenome vervaardigingsbedrywe (100%) die *Enterprise Resource Planning* (ERP) -tegnologie gebruik het vir voorspellingsdoeleindes in die volgende gebiede: materiaal, vraag, produk en produksieskatting. Van die waargenome ondernemings in die vervaardigings- en kleinhandelbedrywe het onderskeidelik 80% en 40% die Materiaalvereistesbeplanningstegnologie (MRP) vir voorspellingsdoeleindes aangewend. Slegs 20% (een projek) van die waargenome bouprojekte het die MRP-tegnologie vir voorspelling in die volgende gebruik: 5% vir vraagvoorspelling (vraagbeheer); 6,7% vir wesenlike voorspelling (voorraadbeheer) en 20% vir produksieskatting (produkuitset). Dit is ook aan die lig gebring dat die gebruik van die voorspellingstegnologie in die konstruksie die volgende voordele kan inhou: behoorlike hulpbronbeplanning; verbeterde produksieskedulering; vermindering in voorraad; effektiewe behandeling van skeduleringsprobleme en die doeltreffendheid van die voorsieningskettingstelsel. Die bevindinge toon dat die effektiewe gebruik van voorspellingstegnologie in die logistieke stelsel van die konstruksiebedryf tot volle effektiwiteitswinste in die voorspellingslogistiek van die konstruksiebedryf kan lei. Dit word aanbeveel dat die Nigeriese konstruksiebedryf gebruik maak hiervan om die beste maniere te kry om die voorspellingstegnologie te hanteer om die voorspellingslogistieke stelsels tydens die konstruksieproses te verbeter.

Sleutelwoorde: DM, ERP, IRES, MRP, konstruksie, logistiek, tegnologie, voorspelling

1. INTRODUCTION

The construction industry is often criticised for delivering projects behind schedules and over budgets, due to its over-reliance on manual modes of operations (Sardroud & Limbachiya, 2010: 1; Sullivan, Barthorpe & Robbins, 2010: 19; Gadde & Dubois, 2010: 254; Tseng, Wu & Nguyen, 2011: 267). According to Navon (2005: 478), this is attributed to the reluctancy of the industry in realising the benefits of the current logistics technology in project performance control. The logistics technology developed to support the management of the Nigerian construction industry in terms of forecasting is outdated, ineffectual, and often overlooked, due to its weak contributions to project performance (Langeley, Coyle, Gibson, Novack & Bardi, 2009: 32).

Logistics management in the manufacturing and retailing industries and its contribution to construction productivity in the use of advanced technologies have not been adequately investigated (Almohsen & Ruwanpura, 2011: 1). Besides, the manufacturing and retailing industries are hardly investigated to inspire new technologies and improved working practice and logistics in the construction industry (Sullivan *et al.*, 2010: 19). Gadde and Dubois (2010: 254) noted that huge efforts must be made in the area of forecasting logistics technology. Although significant attempts have been made in developing technologies, according to Ibrahim and Moselhi (2016: 14), the performance of these systems is still not robust enough for most of the forecasting logistics processes. Hence, choosing an appropriate forecasting technology for various logistics processes is crucial to any construction activity, in order to gain advantage in competitive markets (Bhandari, 2014: 24).

Research evidence has shown that previous studies on construction logistics from different parts of Nigeria have focused on transportation, effectiveness or efficiency in logistics supply chain, and so forth. However, hardly any research focuses on logistics technology, especially the use of forecasting technology, to improve construction logistics processes. Therefore, a wide gap has been identified in the Nigerian construction logistics processes (Samuel & Ondiek, 2014: 9; Fatnani & Malik, 2015: 3253; Braun, Tuttas, Borrmann & Stilla, 2015: 1). However, the technological aspect of construction logistics, especially forecasting, is overlooked, and little is understood in the Nigerian construction industry. It is, therefore, important to examine forecasting-related tasks in the manufacturing, retailing and construction industries; the percentage level of usage of forecasting logistics technologies in the execution of these tasks, and the accruable benefits to construction from the utilisation of the forecasting technology in the industries. The article assesses the level of utilisation of forecasting technology in the manufacturing and retailing industries, in order to improve the forecasting process of the Nigerian construction logistics.

2. LITERATURE REVIEW

In order to understand how to utilise forecasting technology in construction logistics, it is important to introduce the present theory on forecasting and logistics included in this article. The current theory focuses on construction logistics, construction forecasting logistics technology, and forecasting logistics tools used in construction.

2.1 Construction logistics

The term 'logistics' includes activities related to the physical movement of goods, and managing relationships with suppliers and customers (Bhandari, 2014: 19). The word 'logistics' in the construction industry involves a strategic and cost-effective storage, handling, transportation and distribution of resources that enable the primary construction business activity to be accomplished (Sullivan *et al.,* 2010: 4). Therefore, logistics has become part and parcel of every construction business, as no firm or project can succeed without its support (Neeraja, Mehta & Chandani, 2014: 666).

Logistics is a critical component of every construction organisation that requires serious managerial considerations, since it ties up much of the industry's capital (Samuel & Ondiek, 2014: 9). Traditionally, insufficient attention has been paid to construction logistics, and this is obvious in the areas of wasteful procedures, poor productivity performance and inefficiencies (Sullivan *et al*., 2011: 4; Sobotka, Czarnigowska, & Stefaniak, 2005: 203). Hence, logistics management is required at all stages of construction processes, in order to achieve the goals of a construction project (Said & El-rayes, 2014: 110). In addition, Said and El-rayes (2014: 110) believe that better construction logistics planning would require the coordination of supply and site activities by integrating their decisions and recognising existing interdependencies, in order to minimise the total materials management cost. The advantage of coordinated construction logistics is not only to increase productivity, but also to facilitate collaboration, learning and innovation between inter-organisational actors and lower the environmental impact (Bengtsson, 2019: 305).

Thus, completing a construction project within budget and in a timely manner with their numerous constraints requires skillful integration of logistics (Almohsen & Ruwanpura, 2011: 26) and this can influence customer service levels as well as the economic and environmental performance of supply chains (Ying, Tookey & Roberti, 2014: 262).

2.2 Construction forecasting logistics technology

The increasing level of competitiveness in the global construction market has led many construction firms to focus on the application of Information Technology (IT) as a way to improve the integrated process of the construction logistics management (Irizarry, Karan & Jalaei, 2013: 241). In a development by Firat, Woon and Madnick (2008: 1), it was opined that any individual, organisation or nation that used forecasting technology makes proper future decisions. Therefore, high-tech industries face challenges, because their success depends on their capability to grab relatively short-lived opportunities and reduce risks, in order to provide timely technology that will forecast appropriately and make the industry grow (Qin & Nembhard, 2012: 201). New technologies have to be developed in the logistics processes of the construction industry, in order to manage inefficiencies and lower the total production cost (Mohammed & Ali, 2016: 21).

The various logistics technologies for overcoming human errors in the areas of forecasting, tracking and better management of materials are lacking in the construction industry (Fatnani & Malik, 2015: 3253). Moreover, forecasting of resources on construction sites has been a challenging task to construction practitioners. Forecasting technologies are thus suggested in overcoming this challenge (Nasr, Shehab & Vlad, 2013: 1). Forecasting technology is a process of using technology to estimate some future needs that include the needs in quantity size, quality, time and location required, in order to meet the demand for goods or services (Rimawan, Saroso & Rohmah, 2018: 570). Therefore, the forecasting technology should facilitate forward planning and the ability to forecast new projects accurately. This could help construction clients formulate timely and effective corporate strategies (Wong & Ng, 2010: 1265).

In Nigeria, the forecasting of the vast majority of construction sites is mostly done manually. This process is laborious, unreliable, costly and prone to error. In large and complex construction projects, automation of forecasting is required, in order to improve accuracy and reduce the manual efforts (Braun *et al.*, 2015: 1). According to Park, Cho and Kim (2016: 1), problems with the manual process may include time-wasting and inefficient communication among project stakeholders. Bhandari (2014: 24) attributed most of these problems to lack of awareness, fear of innovation and little interest in exploring the benefits of an improved and increased uptake of technology in the forecasting logistics system of the construction industry.

2.3 Forecasting logistics tools

2.3.1 Enterprise Resource Planning (ERP) technology

The term 'ERP' originated from the industry for integrated, multimodules application software packages that aimed to serve and enhance multiple business functions through future forecast (Soliman & Karia, 2015: 265). Therefore, the ERP system is an information system that has integrated broad business task, which is responsible for transaction processing in a real-time environment (Hawking & Sellitto, 2010: 1). This information system is designed to manage all the processes of an organisation to allow and facilitate decision-making from a global perspective of the organisation to suit their processes and characteristics (Ramadhan & Ahmed 2019: 172)

Soliman and Karia (2015: 268) postulate that ERP helps organisations meet the challenges of globalisation with a comprehensive, integrated application suite that comprises next-generation analytics, human capital management, financials, operations, and corporate services. However, many organisations found that the implementation of the ERP system makes it easy for organisations to manage different forecasting tasks such as demand, sales, material, production, and product forecast (Althonayan, 2013: 20).

Althonayan's (2013: 20) review revealed that some important attributes of ERP systems for forecast and their ability to improve organisational effectiveness and efficacy include implementing best business practice, in order to enhance productivity; reduce errors through sharing of data and practice in the enterprise; facilitate rapid and better decision-making that will lead to cost reduction in real time; improve efficiency and effectiveness; improve client receptiveness; increase performance control and data visibility; increase innovative incorporation of business management and IT concepts, and improve automation of business processes in organisations.

The successful implementation of the technology for forecasting can lead to reduced product development cycle, lower inventories, improved customer service and enhanced coordination of global operations (Beheshti & Beheshti, 2010: 446). Bayraktar *et al.* (2009: 22) concluded that the Master Production Schedule (MPS) module in ERP improved demand forecasting for the effective planning of all resources of a manufacturing company. Therefore, as a task for demand forecasting, the ERP technology forecasts stock requirement, purchasing and predicts customer buying habits to optimise the inventory level and meet customer demand (GBS, 2013: 1).

2.3.2 Material Requirement Planning (MRP) technology

The MRP technology is a production planning and control system used to forecast and coordinate order fulfilment, by synchronising the availability of materials and resources to customer demand, which could result in better resource planning and reduced inventory level, through releasing purchase and/or work orders (Bayraktar *et al.*, 2009: 136). The technology provides a relatively fast, real and effective treatment of scheduling problems, diminishing cost production of orders, due to minimum inventory mitigation, time accuracy of materials and parts reception (Imetieg & Lutovac, 2015: 58). Information about competitive products and customers' reactions are forecast with the help of MRP technology (Malthouse, Haenlein, Skiera, Wege & Zhang, 2013: 270).

This technology provides good information necessary for effective decision-making (Madapusi & Souza, 2012: 24). A small saving in material cost through efficient and effective use of MRP technology for the management of materials can result in a large saving in the total project cost (Deepa & Eldhose, 2018: 32). Shi, Asce and Halpin (2003: 214) further discovered that the current ERP technology is primarily developed for manufacturing. They put forward the ERP system for construction, by addressing the nature and business culture of the industry. The successes recorded by the manufacturing and retailing industries in advanced countries led to the trial of the ERP system in the construction industry (Acikalin, Kuruoglu, Isikdag & Underwood, 2009: 245).

2.3.3 Inventory Replenishment Expert System (IRES) technology

The IRES technology is based on a periodic review inventory control and time series forecasting techniques, which propose the most effective replenishment strategy for each supply classed derived from an ABC-XYZ Analysis (Errasti, Chackelson & Poler, 2010: 129). For a company to achieve a balance between efficiency and responsiveness, there is a need for IRES, which is less expensive accurate information, timely, reliable and consistent (Samuel & Ondiek, 2014: 10). Errasti *et al.* (2010: 135) added that IRES is a useful tax for demand forecast, sales forecast, production forecast, minimizing inventory level, and increasing service quality.

2.3.4 Data Mining (DM) technology

DM technology is a tool used for forecasting customers' task, by analysing customers' performance in the past (demand, sales, material, production, and product forecast) (Xie, 2009: 19). Chiang, Lin and Chen (2011: 220) found that DM technology is developed to extract useful information from the bulk of data, and discover which products commonly appear in customer orders. Simultaneously, the information of product association can be used to generate storage assignment rules for improving efficiency in the industry. DM is the method of analysing data from different outlooks and summarising it into useful information, by providing data access to business analysts and information technology professionals (Dokania & Kaur, 2018: 202).

DM technology can help identify customer behaviour; reveal customer shopping patterns and trends; improve the quality of customer service; achieve better customer retention and satisfaction; enhance goods consumption ratios; design more effective goods transportation and distribution policies, as well as reduce the cost of business (Paidi, 2012: 4660). Research conducted by Ramageri and Desai (2013: 47) shows that DM technology performed the task of demand forecasting, sales forecasting, production forecasting, competitors forecasting and extraction of hidden predictive information from very large databases, with great potential to help organisations predict future trends and behaviours.

2.3.5 Manufacturing and retailing industries' experiences of forecasting logistics technology

The manufacturing and retailing industries have recorded tremendous achievement in the development and usage of forecasting technology in demand, sales, material, production, and product forecast (Althonayan, 2013: 20). The technology has been able to forecast customers, products or geography, using past data trends, which can be extended to the future, from the transaction that has been captured. Althonayan (2013: 20) revealed that some important attributes of forecasting technology systems in manufacturing industries are their ability to improve organisational effectiveness and efficacy, including productivity enhancement; reduce errors through sharing of data and practice; increase performance control and data visibility, and improve automation of business processes in organisations.

3. RESEARCH METHODOLOGY

3.1 Research design

This study uses a mixed methods approach where both quantitative and qualitative data are collected in parallel, analysed separately, and then merged (Creswell & Plano-Clark, 2018: 8; Grbich, 2013: 27). In this study, the quantitative semi-structured questionnaire survey was investigated by observations of the task performance of forecasting-related technology (ERP, MRP, IRES, and DM) from the manufacturing, retailing and construction sectors. The qualitative interviews explored the benefits of implementing forecasting technologies in the construction sector. The qualitative method allows in-depth understanding, discovery, and clarification of the situation. It provides the researcher with a unique avenue to probe responses or observations (Guest, Namey & Mitchell, 2013: 21). The reason for collecting both quantitative and qualitative data is to elaborate on specific findings from the breakdown of the interview transcripts, and to cross-check the data against the questionnaire data set such as similarities in the use of forecasting-related technology.

3.2 Population, sampling methods and response rate

The geographical study areas for this study included the manufacturing, retailing and construction sectors in Lagos State and Abuja, the Federal Capital Territory (FCT) of Nigeria. These geographical study areas were selected, because they both have many manufacturing and retailing companies and many construction projects. Moreover, these two cities are among the metropolitan cities in Nigeria with the highest population of professionals within the built environment with many ongoing construction projects.

For the quantitative semi-structured questionnaire survey, purposive sampling was used to select a sample of 15 companies (including five manufacturing, five retailing and five construction companies) with projects of 2.8 billion Naira and above, as at 28 August 2017. Purposive sampling allows for the selection of individuals or organisations, based on their experiences, to yield adequate information about the topic under investigation (Leedy & Ormrod, 2014: 154). For this study, companies with projects to the capital base/value of 2.8 billion Naira and above are deemed mature enough and presumed to have advanced technologies such as ERP, MRP, IRES, and DM (Soliman & Karia, 2015: 265). According to Leedy and Ormrod (2014: 67), the typical qualitative research sample size for observations ranges between five and 25 participants. For qualitative data collection, purposive sampling was used to sample 15 participants (workers each from the different sectors visited who were stationed to work on the technology) who simultaneously participated in the interviews. Purposive sampling allows the researcher to choose participants based on their characteristics, pre-knowledge and capability of providing adequate knowledge deemed necessary for a study (Bless, Higson-Smith & Sithole, 2013: 172).

3.3 Data collection

An observation guide and semi-structured interviews were used to observe only the forecasting technology utilised in five ERP technology from manufacturing companies; seven MRP technology, including four MRP technology from manufacturing companies; two MRP technology from retailing companies, and one from construction projects. Six IRES technology were observed, including two IRES technology from manufacturing companies and four from retailing. Only two DM technologies were observed from manufacturing companies. The oberservation guide included seven main forecasting tasks for the manufacturing and retailing companies, namely demand, sales, material, production, product, competitors, and advertisement as well as five main tasks for construction companies, namely demand, stock, production, procurement, and procurement process.

The observations were carried out with the aid of the workers in the sectors (manufacturing, retailing, and construction) who were stationed to work on the technologies. The observations were done by taking the researcher around the forecasting technologies available. Questions were asked on the task performed by the technology in the industry and the related tasks and subtasks that the same technology could perform in the construction industry. The observations were only based on the forecasting logistics technologies available (see Tables 1 to 4).

The respondents of the semi-structured interviews were one worker each from the different sectors visited who was stationed to work on the technology. This included five respondents from manufacturing companies for the ERP technology; for MRP, four respondents from manufacturing companies, two respondents from retailing companies and one respondent from a construction sector, making a total of seven respondents from the companies; for IRES, two respondents from manufacturing companies and four respondents from retailing companies, making a total of six respondents from the companies, and for the DM technology only two respondents from manufacturing companies.

The semi-structured interview guide contains only one major question: How can the benefits of utilising these forecasting logistics technologies be accruable to the logistics forecasting of the construction industry? (See the last column of Tables 1 to 4.)

3.4 Data analysis and interpretation

The collected quantitative data (observations) for this study were analysed, using descriptive analytical tools that included frequencies and percentiles. The tabulated results from the instruments were divided into two parts. The first part consisted of the related tasks in the manufacturing and retailing industries, and the second part consisted of tasks and subtasks in the construction industry. In the first part, the technologies were identified in five manufacturing and five retailing companies, thus a total of ten companies. The identification in each of these companies represented 20% of the 100% for the five manufacturing and the five retailing companies, respectively. In addition, the tasks in the five manufacturing and retailing companies were identified, with each occupying 20% of the 100%. For example, demand forecast in Table 2 was used by four of the five manufacturing companies, each company occupying 20%. This means 20% multiplied by four industries equals 80% of the 100% of the five manufacturing companies.

Table 1: Enterprise Resource Planning (ERP) technology

Manufacturing and retailing industries							*Construction industries*			
		Manufacturing		Retailing		Construction				
Percentage identification		100		0		0				
Tasks in manufacturing and retailing		*100%*	*% Level of usage*	*100%*	*% Level of usage*	*100%*	*% Level of usage*	*Tasks in construction*		*Benefits accrued*
								Subtasks	*Main tasks*	
1	Demand forecast	80	20					Material demand on site	Demand control	Accurate estimate, improved business processes, help in improving customer service
								Labour demand on site		
								Equipment demand on site		
								Plant demand on site		
2	Sales forecast	80	20							
3	Material forecast	100	25					Material on site	Stock control	Accurate estimate, speed of planning, maximize gain and minimize loss
								Order management		
								Material to be used		
4	Production forecast	60	15					Labour output	Production output control	Increased production efficiency
								Plant output		
5	Product forecast									
6	Competi-tors forecast	40	10					Bidding	Procurement	Maximize gain and minimize loss from future condition, improved and faster information among different sections
7	Advertise-ment forecast	40	10					Invitation for tender	Procurement process	Forecasting in real time
								Submission of tender		
								Tender evaluation and report		
Total		400	100							

The same process applies to the five retailing companies. Moreover, for identification of the technologies in the five construction projects, each occupied 20% of 100%. The tasks that correspond to the manufacturing and retailing companies were also identified, each occupying 20% of 100% for the five projects in the construction industry.

The tasks under the construction project were subdivided into subtasks, for which 20% occupied by each project was further subdivided into the subtasks under the projects in the construction projects. This means that demand control only occupied 20%, which will be divided among the number of subtasks that appear under demand control. For example, the corresponding task to demand forecast in construction is demand control in Table 2. Therefore, demand control as a main task, each occupying 20% to make 100%, the 20% under "demand control" was further divided into four different subtasks in demand control (material demand on site, labour demand on site, equipment demand on site, and plant demand on site) that is, 20% divided by four equals 5% for each subtask. Furthermore, the total of these percentages from the manufacturing, retailing and construction industries were utilised to produce the percentage level of usage of the tasks and subtasks in the three industries. This was done by dividing each percentage unit of the task by the overall percentage total of the industries (manufacturing + retailing + construction) and multiply by 100%.

For example, using this formula L=U/T x 100%, where U=Unit percentage of one task of the three industries; T=Total percentage of manufacturing, retailing and construction industries, and L=Percentage level of usage of each unit percentage task. In addition, the total percentage and percentage proportion of tasks in the three industries were used to develop Figures 2 and 3 for MRP and IRES, respectively.

Using thematic data analysis, a nuanced account of the data could be presented by transcribing, coding and setting themes from the responses of the focus-group interviews (Clarke & Braun, 2013: 120). For this study, all shared experiences during the interviews with workers/operators were recorded and used as the interview data. Using Microsoft Excel (Bowen, Edwards & Cattel, 2012: 887), the raw data on the relevant benefits of the technology that could accrue to the tasks and subtasks in the construction logistics processes in Nigeria was analysed and categorised into conceptual themes, including benefits accruing for demand, stock, production, procurement, and procurement process.

3.5 Limitations

In the course of the data collection, access to some organisations, particularly the manufacturing and retailing sectors, was denied, as some information

Table 2: Material Requirement Planning (MRP) technology

Manufacturing and retailing industries						*Construction industries*				
		Manufacturing		Retailing		Construction				
Percentage identification		80		40		20				
Tasks in manufacturing and retailing		*100%*	*% Level of usage*	*100%*	*% Level of usage*	*100%*	*% Level of usage*	*Tasks in construction*		*Benefits accrued*
								Subtasks	*Main tasks*	
1	Demand forecast	80	17.7	40	8.9	5		Material demand on site	Demand control	Reduced inventory, fast, real and effective treatment of scheduling problems, provides critical information streams necessary, lessening cost of production
							1.1	Labour demand on site		
								Equipment demand on site		
								Plant demand on site		
2	Sales forecast	40	8.9							
3	Material forecast	80	17.7	40	8.9	6.7		Material on site	Stock control	Improved resource planning and reduced inventory level
							1.5	Order manage-ment		
								Material to be used		
4	Production forecast	60	13.3					Labour output	Production output control	Improved production scheduling, capacity planning, material requirement planning and inventory management
								Plant output		
5	Product forecast	40	8.9	40	8.9	20	4.4	Programme of work	Product output	Efficiency of a supply-chain system, fast, real and effective treatment of scheduling
6	Competitors forecast							Bidding	Procurement	
7	Advertisement forecast							Invitation for tender	Procurement process	
								Submission of tender		
								Tender evaluation and report		
Total		300	66.5	120	26.7	31.7	7			

was considered strictly confidential and, therefore, not to be disclosed to researchers. Moreover, some organisations, particularly in the construction sectors, do not have the related technology under consideration. The researcher had to move on to consider only those that have the technology.

4. RESULTS AND DISCUSSION

4.1 Enterprise Resource Planning (ERP) technology

Table 1 shows that all the manufacturing industries adopted ERP technology for forecasting purposes, of which 80% of this industry used ERP technology for demand forecast. This result corroborates the findings of Belbağ, Çimen, Tarim and Taş (2009: 489) that, as a forecasting tool, demand planning in the manufacturing industry enhances the profitability of a product. GBS (2013: 1) and Nenni, Giustiniano and Pirolo (2013: 1), however, opine that the profitability of demand forecasting varies according to a company and an industry.

Moreover, 100% and 60% of the manufacturing industry used ERP technology for material forecast and production forecast, respectively. The results are in line with the findings of Chryssolouris, Papakostas Mourtzis, Michalos and Georgoulias (2009: 454) and Zhu, Li, Wang and Chen (2010: 266) on the use of ERP technology for customers' products in improving efficiency. The results also corroborate the finding of Bayraktar *et al.* (2009: 136) on master production schedule module that provides feedback for the effective planning of all the resources of a company. Furthermore, 40% of the manufacturing industry used ERP technology for competitors and advertisement forecasting. These results validated the findings of Firat *et al.* (2008: 3) and Althonayan (2013: 20), on advertisement.

Surprisingly, ERP technology was not found for forecasting tasks in the retailing and construction industries.

The respondents in the construction projects studied revealed that, although they did not fully utilise the ERP technology, the latter could be utilised to improve the following area of construction logistics tasks:

- Demand control: Material demand on site, labour demand on site, equipment demands on site and plant demand on site.
- Stock control: Material on site, order management and material to be used.
- Production output control: Labour output and plant output.
- Procurement: Bidding process.
- Procurement process: Invitation to tender, submission of tender, tender evaluation and report.

4.2 Accruable benefits of ERP technology to construction

Table 1 clearly shows that the interviewed respondents deemed that the following benefits could be accrued to the construction industry if the ERP technology is utilised in the construction industry for forecasting processes of logistics management, including determination of an accurate estimation, so that the actual construction cost does not deviate a great deal from the project cost of the undertaking; increased speed of the planning process in construction; increased efficiency of construction work by providing an overall view of the scenario of the project prior to making decisions; construction forecasting in real time; improved construction processes; improved construction customer service, as well as improved and faster information among different sections of construction.

These results support the finding of Althonayan (2013: 20) that ERP technology provides an accurate estimate and forecast in real time. The results also validate the findings of Addo-Tenkorang and Helo (2012: 3) and Ociepa-Kubicka (2017: 240), who mentioned the benefits of ERP to include enhancing business processes, facilitating the smooth flow of common functional information, and that good forecasting can help maximise gain and minimise loss from future conditions (Firat *et al.,* 2008: 3).

4.3 Material Requirement Planning (MRP) technology

A total of 80% and 40% of the manufacturing and retailing industries, respectively, used MRP technology for forecasting purposes, when compared to the construction industry that used only 20% of the MRP technology for forecasting. These results confirm Samuel and Ondiek's (2014: 11) finding that MRP was used mostly in the manufacturing industry.

In terms of demand forecast, 80% and 40% of the manufacturing and retailing industries, respectively, used the MRP technology for demand forecast. However, in the construction industry, only 20% used the MRP technology for demand forecasting (demand control). Moreover, 40% of the manufacturing and retailing industries used the MRP technology for product forecast, whereas 20% of the construction industry used it for production forecast (production output). These results support the findings of Samaranayake (2012: 435), Kandananond (2012: 1) and Sarkar *et al.* (2014: 653) on the correctness of demand forecasts to expand production scheduling.

Moreover, for the sales and production forecast, the manufacturing industry used 40% and 60%, respectively. The results are in line with Imetieg and Lutovac's (2015: 58) findings on effective forecasting to reduce the cost of a product.

Therefore, the respondents in the construction projects studied revealed that, although they did not fully utilise MRP technology, the latter could be utilised to improve the following area of construction logistics tasks:

- Demand control: Material demand on site, labour demand on site, equipment demand on site and plant demand on site.
- Stock control: Material on site, order management and material to be used
- Production output control: Labour output and plant output
- Procurement: Bidding process
- Procurement process: Invitation to tender, submission of tender, tender evaluation and report.

4.4 Accruable benefits of MRP technology to construction

Table 2 shows that the interviewed respondents deemed that the following benefits could be accrued to construction industry if MRP technology is utilised in the construction industry for forecasting processes of logistics management. These include provision of better resource planning and reduced inventory level on the construction site; provision of accuracy of demand forecasts on the construction site; provision of production scheduling, capacity planning, MRP and inventory management in construction industries; provision of efficiency of a supply-chain system on site; provision of relatively fast, real and effective treatment of scheduling problems; reduction in the cost of production orders in construction works, and provision of critical information streams necessary for effective decision-making.

These results support the findings of Kandananond (2012: 1) and Imetieg and Lutovac (2015: 58) that MRP technology leads to better resource planning, efficiency of supply, fast treatment of scheduling planning, and lower cost of production. These also validate the findings of Samaranayake (2012: 435) and Madapusi and Souza (2012: 24) that MRP provides the following benefits: Planning of materials and resources, scheduling of operations for various units, and providing critical information streams necessary for effective decision-making.

Figure 1 shows that the total use of tasks using MRP technology is 300, 120 and 31.7 in the manufacturing, retailing and construction industries, respectively; each occupies a proportion of 66.5%, 26.7% and 7% across the three industries, respectively. This meant that the utilisation of MRP technology in the construction industry for forecasting was very low when compared to the manufacturing and retailing industries.

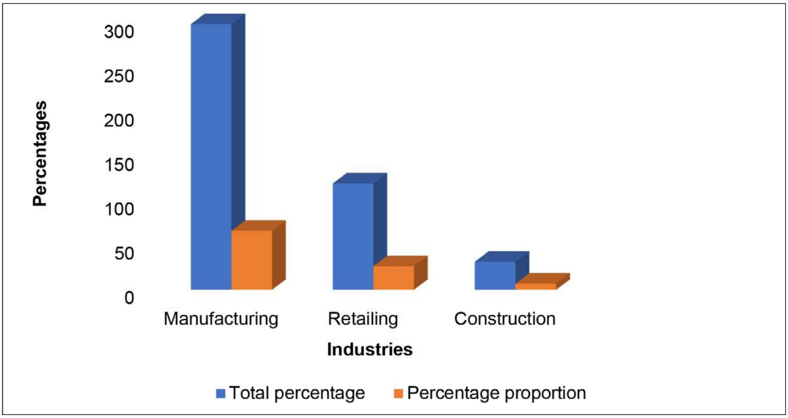

Figure 1: Material Requirement Planning (MRP) technology percentage utilisation

4.5 Inventory Replenishment Expert System (IRES) technology

A total of 40% and 80% of the manufacturing and retailing industries, respectively, adopted IRES technology for forecasting purposes, from which 40% and 20% of the manufacturing and retailing industries, respectively, used IRES technology for product forecast. These results confirm the finding of Richey *et al* (2010: 84) in section 2 of this study.

In terms of material forecast, 40% and 80% of the manufacturing and retailing industries, respectively, used IRES technology for material, while, for product forecast, 20% and 60% are used for IRES technology in manufacturing and retailing industries, respectively. Most of these results corroborate the findings of Errasti *et al.* (2010: 129) and Jaipuria and Mahapatra (2014: 2405) on IRES technology to offer the most effective timely replenishment strategy for each material supply, useful for prediction purposes.

It is surprising that IRES technology was not found to forecast tasks in the construction industry. The respondents in the construction projects studied revealed that, although they did not fully utilise IRES technology, it could be utilised to improve the following area of construction logistics tasks:

- Demand control: Material demand on site, labour demand on site, equipment demand on site and plant demand on site.
- Stock control: Material on site, order management and material to be used.
- Production output control: Labour output and plant output.
- Procurement: Bidding process.

- Procurement process: Invitation to tender, submission of tender, tender evaluation and report.

4.6 Accruable benefits of IRES technology to construction

Table 3 shows that the interviewed respondents deemed that the following benefits could be accrued to construction industry if IRES technology is utilised in the construction industry for forecasting processes of logistics management. These include provision of accurate information of material on the construction site; reliable and consistent information; minimised inventory levels in the construction industry; increased service quality in the construction industry; increased productivity in the construction industry; increased efficiency of a supply-chain system on site; improved scheduling, and material planning.

These results support the findings of Errasti *et al.* (2010: 135) and Samuel and Ondiek (2014: 10) who conclude that IRES technology provides reliable information and increasing service quality. Richey *et al.* (2010: 84) also focus on increased productivity.

Figure 2 shows that the total use of the tasks using IRES technology is 100 and 240 in the manufacturing and retailing industries, respectively, occupying proportions of 29% and 71% in the two industries, respectively. This meant that IRES technology is not found in the construction industry for forecasting.

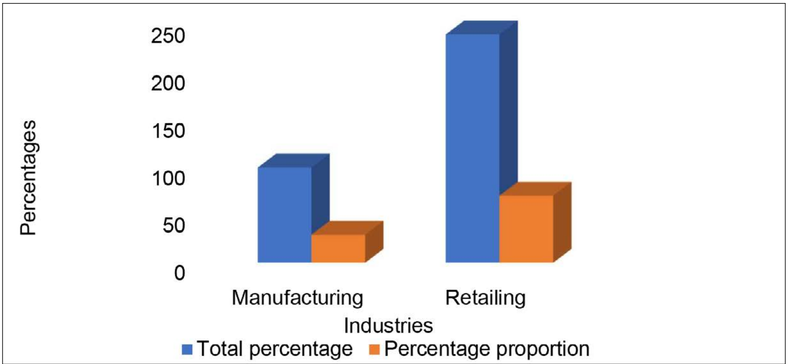

Figure 2: Inventory replenishment expert system (IRES) technology

4.7 Data Mining (DM) technology

A total of 40% of the manufacturing industry adopted DM technology for forecasting purposes, of which 40% of the manufacturing industry used DM technology for demand forecasting and sales forecasting. These results support the findings of Krause-Traudes *et al.* (2008: 3) and Xie (2009: 19)

Table 3: Inventory replenishment expert system (IRES) technology

Manufacturing and retailing industries						*Construction industries*				
		Manufacturing		Retailing		Construction				
Percentage identification		40		80		0				
Tasks in manufacturing and retailing		*100%*	*% Level of usage*	*100%*	*% Level of usage*	*100% Subtasks*	*% Level of usage Main tasks*	*Tasks in construction Subtasks*	*Main tasks*	*Benefits accrued*
1	Demand forecast	40	11.8	20	5.9			Material demand on site	Demand control	Accurate information of material, reliable, consistent information and improved scheduling, and material planning
							Labour demand on site			
							Equipment demand on site			
							Plant demand on site			
2	Sales forecast			80	23.5					
3	Material forecast	40	11.8	80	23.5			Material on site	Stock control	Accurate information of material, minimised inventory level, increased productivity and efficiency of a supply chain
							Order manage-ment			
							Material to be used			
4	Production forecast	60	13.3					Labour output	Production output control	Increased service quality
							Plant output			
5	Product forecast	20	5.9	60	17.6			Programme of work	Product output	Increase productivity, reliable consistent information and efficiency of a supply chain.
6	Competitors forecast							Bidding	Procurement	
7	Advertisement forecast							Invitation for tender	Procurement process	Increassd service quality of work
							Submission of tender			
							Tender evaluation and report			
Total		100	29.5	240	70.5					

on the use of demand forecasting for DM technology, as stated in section 2 of this study.

Furthermore, 20% of the manufacturing industry used DM technology for production and competitors forecast. These results are in line with the finding of Chiang *et al*. (2011: 220) on the information of production and product for improving industries' efficiency.

The respondents in the construction projects studied revealed that, although they did not fully utilise DM technology, the latter could be utilised to improve the following area of construction logistics tasks:

- Demand control: Material demand on site, labour demand on site, equipment demand on site and plant demand on site.
- Stock control: Material on site, order management and material to be used
- Production output control: Labour output and plant output
- Procurement: Bidding process
- Procurement process: Invitation to tender, submission of tender, tender evaluation and report.

4.8 Accruable benefits of DM technology to construction

Table 4 shows that DM technology is not used in the construction and retailing industries for forecasting. Therefore, the interviewed respondents deemed that the following benefits could be accrued to the construction industry if DM technology is utilised in the construction industry for forecasting processes of logistics management: increased worker satisfaction in the construction industry; enhanced good construction design; provision of more effective goods transportation and distribution; reduced cost of construction; help organisations make proactive knowledge-driven decisions on construction; prepare databases to find hidden patterns in construction; find predictive information about the construction; increased labour productivity on site; reduction in the processing time of material on the construction site; improved use of the plant in the construction industry, and improved construction team experience.

Coincidentally, all these results support the findings of Paidi (2012: 4660) and Ramageri and Desai (2013: 47) that the technology enhances good construction. Moreover, these results are in line with the findings of Luis *et al.* (2012: 5529) and Greitemann *et al.* (2016: 32) that technology provides a better experience for the workers and reduces processing time.

Table 4: Data Mining (DM) technology

Manufacturing and retailing industries						*Construction industries*				
		Manufacturing		Retailing		Construction				
Percentage identification		40		0		0				
Tasks in manufacturing and retailing		*100%*	*% Level of usage*	*100%*	*% Level of usage*	*100%*	*% Level of usage*	*Tasks in construction*		*Benefits accrued*
								Subtasks	*Main tasks*	
1	Demand forecast	40	33.3					Material demand on site	Demand control	Reduced cost of construction and improved use of the plant
								Labour demand on site		
								Equipment demand on site		
								Plant demand on site		
2	Sales forecast	40	33.3							
3	Material forecast							Material on site	Stock control	Enhanced good design and make proactive knowledge-driven decisions, prepare databases and reduction in the processing time of the material
								Order management		
								Material to be used		
4	Production forecast	20	16.7					Labour output	Production output control	Increased labour productivity
								Plant output		
5	Product forecast									
6	Competitors forecast	20	16.7					Bidding	Procure-ment	Improved customer retention, making proactive knowledge-driven decisions, predictive information and better construction team experience
7	Advertisement forecast							Invitation for tender	Procure-ment process	
								Submission of tender		
								Tender evaluation and report		
Total		120	100							

5. CONCLUSION

The technological aspect of construction logistics, especially the forecasting, is overlooked and hardly understood in the Nigerian construction industry. This article assessed how ERP, MRP, IRES, and DM technologies could be utilised in the manufacturing and retailing industries to improve the forecasting processes of construction logistics.

Findings showed that all of the observed manufacturing industries (100%) adopted ERP technology for forecasting purposes (for material, demand, product, and production forecasts). Surprisingly, ERP technology was not used for forecasting in the retailing and construction sectors.

In addition, 80% and 40% of the observed companies in the manufacturing and retailing sectors, respectively, adopted MRP technology for forecasting purposes. Only 20% (one project) of the observed construction projects adopted MRP technology for forecasting in the following: 5% for demand forecast (demand control); 6.7% for material forecast (stock control), and 20% for product forecast (product output).

Moreover, 40% and 80% of the observed manufacturing and retailing sectors, respectively, adopted IRES technology for forecasting purposes; 40% of the observed companies in the manufacturing industry adopted DM technology for forecasting purposes. Based on these findings, it can be concluded that ERP, IRES and DM technologies were not used for forecasting purposes in the retailing and construction sectors, whereas the MRP technology is not fully used in the construction projects when compared to the manufacturing and retailing industries.

Due to the ultimate benefit that could accrue to the construction industry for the utilisation of the forecasting technology for forecasting purposes (namely achievement of full forecasting-efficiency gains in construction), ERP, MRP, IRES, and DM technologies could be utilised in the construction industry to improve the following tasks in the construction industry: demand control: material, labour, as well as equipment and plant demand on site; stock control: material on site, order management, and material to be used; production output control: labour output and plant output, and procurement process: bidding process, invitation to tender, submission of tender, tender evaluation and report. To this end, the Nigerian construction industry should leverage on this, in order to create the best ways of handling ERP, MRP IRES, and DM technologies to improve the forecasting logistics systems of the construction process.

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