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MULTILAYER PERCEPTRON NETWORK MODEL FOR CONSTRUCTION MATERIAL PROCUREMENT IN FAST DEVELOPING CITIES

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ABSTRACT

Material contributes greatly to the total cost of construction. Effective material procurement can yield significant cost savings, profit maximization and improved client satisfaction. The aim of the study was to predict factors with the greatest influence on material procurement. The study adopted a cross sectional survey research design, with the aid of 85 questionnaires distributed to contractors on the mainland area of Lagos metropolis, Nigeria. Data obtained were analyzed using multilayered perceptron network model. The findings reveal volume of order and reputation of manufacturers/suppliers as the strongest variables predicting the outcome of material price while time of material order and current sales were found to predict material quality. Moreover, the study predicted that material price during procurement is unstable. At some time material prices are docile and pick up gradually while at other times material prices appreciate and suddenly crash. The findings of the study have strong implications for material procurement in construction site, particularly in fast developing cities. The study recommends the adoption of effective material procurement system that will bring about tradeoffs between material price, material quality and time of material order all of which are important in achieving construction project objectives.

Key words: construction sites, developing cities, material procurement, network model, project performance

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1. INTRODUCTION

A major feature of fast developing cities is the rapid development of buildings and civil infrastructure. The study area Lagos Nigeria has been described as the 7th fastest growing city in the world (City mayor statistics, 2016). In recent times the architectural landscape of Lagos metropolis has been totally transformed. From new road construction, to bridges, rails and even the ambitious Lagos Atlantic city; a 10million square meters prime estate built on reclaimed land from the Atlantic Ocean.

Not only has there been an increase in number of construction works both on the mainland and island areas of Lagos, the speed of construction has also been remarkable. Developers are in a haste to complete construction work so as to gain early return on investment. Speed of construction also means that large volume of materials is procured to site. However, speed of construction and volume of material procured may have negative implication on the quality of construction. Poor construction leads to rework, time overruns and eventual cost overruns. In an era of dwindling economic resources, the adoption of effective material procurement can yield significant cost savings, profit optimization and improved client satisfaction (Phu and Cho, 2014; Karlson, 2009).

Material is an important construction resource which contributes greatly to the total cost of construction. Material alone can consume up to 60% of total construction cost (Gulghane and Khandve, 2015; Patil, Smita and Pataskar, 2013 and Ibironke 2013). Moreover, material cost has been found to be the most significant factor affecting cost of construction (Tunji-Olayeni, Lawal and Amusan, 2012).

Material procurement is an integrated process consisting of people, organizations, technology, and procedures used to effectively identify, quantify, acquire, expedite, inspect, transport, receive, store, and preserve the materials, equipment, and associated information across the life cycle of a project (Caldas et al., 2015). The goal of material procurement is to ensure that materials are available at their point of use when needed hence, effective procurement of material is a major requirement for successful project delivery (Patil, Smita and Pataskar, 2013; Caldas et al., 2015; Gulghane and Khandve, 2015).

The aim of the research was to predict the factors affecting material procurement on construction sites.

2. LITERATURE REVIEW

2.1. Material Procurement and Project Performance

Procuring the right material at the right place at the right time in the right quantity can greatly help reduce material waste which leads to economic inefficiency. According to Patil, Smita and Pataskar (2013) proper material procurement minimizes project cost. Material is certainly a significant resource in the construction process and it covers a large proportion of construction cost. It has been observed that material consumes up to 60% of total construction cost (Gulghane and Khandve, 2015; Patil, Smita and Pataskar, 2013 and Ibironke 2013). Moreover, material procurement challenges including material shortages and material delay inhibit the timely flow of materials and have been found to cause project delays (Gulghane and Khandve, 2015; Kasim, Anumba, and Dainty, 2005; Dey 2001 and Ogunlana, 1996). For instance, late delivery or delivery of incorrect quantity of material often affects the time plan in a project (Darvik and Larsson, 2010). In addition, delivery challenges on construction site account for 8-25% of non-complete activities (Ala-Risku and Kärkkäinen, 2006). The huge cost implication of construction materials in comparison with other construction resources makes material management and material procurement in particular, to impact greatly on project performance. Therefore effective material procurement can bring about significant cost savings and overall improvement of project performance. However, Ibegbulem and Okorie (2015) noted that material procurement is a highly technical area which requires the skill and experience of a procurement manager. Ayoade (2004) added that the procurement circle consists of recognizing, defining and describing the need; transmitting the need, investigating and selecting the supplier, order, receipt and inspection of good supplied, auditing the invoicing and closing the order. Procuring materials before needed on site results in deterioration, theft and eventual waste. For instance, Bertelsen & Nielsen (1997) noted that early material deliveries and large order quantities contribute to disorder on site, extra handling, breakage and loss of material, which is costly and leads to waste. Storage of material also increases the risk of theft, which in turn results in extra costs for new material and administration (Darvik and Larsson, 2010). In the same vein, delays in ordering material leads to significant loss of productivity on site (Dey, 2001). Supply of poor quality material during procurement negatively affects project performance. Use of inferior material causes extra tangible and intangible costs. Tangible costs due to supply of poor quality material include rework and warranty costs while intangible costs include increased project time (Campanella, 1999).

Supply of defective or poor quality material can also lead to a phenomenon called external costs. In the construction context, external costs are cost borne by the contactor in order to correct errors identified by the client, process clients' complaints, resolve clients' claims and disputes and loss of reputation (Van Weele, 2005). From the foregoing, several factors including material price, material quality, quantity of material, suppliers'/manufacturers' reputation, waiting time, and volume of order have been found to affect material procurement. In an era of dwindling construction resources, there is a need to empirically determine the factors that strongly predict material procurement, in order to achieve tradeoffs required for the desired project objectives. Hence, the study attempted to predict the factors strongly affecting material procurement on construction sites.

3. METHODOLOGY

The research adopted a cross sectional survey research approach with the aid of questionnaire. Well-structured questionnaires were distributed to contractors in Lagos, Nigeria on a convenience sampling basis. The questionnaire was divided into two (2) sections. Section one sought answers to factors affecting material purchase while section 2 was on demographic information of the contractors. Eighty-five (85) copies of the questionnaire were distributed out of which 55 were properly filled and returned. Two main types of analyses were conducted. The first analysis was descriptive statistics while the second analysis was multilayered perceptron network model.

4. FINDINGS AND DISCUSSIONS

4.1. Descriptive Statistics

4.1.1. Personnel in charge of logistics

Table 1 shows that in 20 of the firms surveyed, project managers are saddled with logistics responsibility while 17 of the firms have logistics officers who handle logistics. In 13 of the firms surveyed logistics is controlled by the purchasing department and only 5 of the firms have company owners who are directly involved in logistics.

Table 1 Personnel/department in charge of material logistics

Personnel/department	Frequency
Purchasing department	13
Logistics officer	17
Project manager	20
Owner	5
Total	55

From table 1, it can be deduced that even though most of the owners of construction firms in the study site do not saddled themselves with the responsibility of material logistics, it is the project manager rather than any other team member that handles material logistics.

4.2. Method of Forecasting Material Demand

Table 2 indicates that 3 of the firms surveyed make use of experience in forecasting material demand while 43 firms forecast material demand as work progresses. Process flow chart is used by 8 firms while only 1 of the firms surveyed used logistics software in forecasting material demand.

Table 2 Method of forecasting material demand

Method	Frequency
Experience	3
Work progress	43
Process flow chart	8
Logistics software	1
Total	55

Table 2 reveals that most construction firms use work progress to forecast material demand. This may be as a result of the fact that when materials are purchased before needed on site, deterioration, theft and waste may occur.

5. MULTILAYER PERCEPTRON NETWORK MODEL

In the neural network outlook (figure 1), price was the dependent variable, quality was the factor while capability of purchasing officer, waiting time, volume of order, sales order and reputation of manufacturer/supplier were the covariates. The ratio of training to testing data is 18:5 which affirms the validity of the outcome in the study area (Gath, 2008). Hence, the result supports the idea of Hakan and Elçin (2007) that contractors can select more than one alternative (i.e. capability of purchasing officer, waiting time, volume of order, sales order and reputation of manufacturer/supplier), to calculate cost of materials purchased when determining the average cost of a construction project. Hence, the choice of alternatives used in this research can greatly influence cost estimation during material procurement.

From the first perceptron (figure 1) it can be seen that volume of order and reputation of manufacturer/supplier are the strongest variables predicting the outcome of material price and quality. Hence, volume of order and reputation of manufacturer/supplier could initiate a bias that could compromise price and quality. Established manufacturers/suppliers enjoy good will as a result of the reputation they have built over the years. Contractors prefer to patronize suppliers/manufacturers with good reputation in order to avoid intangible quality costs arising from supply of poor quality material and also external costs arising from errors identified by the client, clients' complaints, claims, disputes and loss of reputation when defective or poor quality material is supplied.(Van Weele, 2005). Selecting a manufacturer/supplier with poor reputation could initiate a bias that could compromise price and quality. Typically, contractors are likely to order materials in bulk in order to enjoy sales discount. Ordering large volume of materials at once could initiate a bias that could compromise price and quality. However, when materials are ordered in large quantities to sites where there is an inadequate storage facility, a lot of effort is wasted on material handling and storage which translates to extra costs. Moreover, quality could be compromised when material is mass produced and correcting defects in material leads to extra cost.

On the second perceptron (Figure 1), there are two variables predicting the outcome of quality: time of material order and current sales. During peak sales or production period, errors and quality issues are likely to occur as suppliers/manufacturers strive to meet deadlines. In other words, emphasis on material quality may depend on time of order and current sales. This implies that material procurement for projects in fast developing cities is likely to significantly depend on the two perceptron discussed. This result is largely corroborated by the normalized importance shown in Figure 2. The influence of time (which was about 60%) on construction projects may influence material sales to about 52%.

Moreover, the price prediction (Figure 3) reveals the possibility of three characteristics of the material pricing system in the research site. Most importantly is the possibility of falling or appreciating price system (see Figure 4). The pricing system may be initially docile and start picking – up under certain bias (Type 1) or the pricing system may appreciate and then crash under certain bias (Type 2). Since prices are subject to long and unpredictable swings, the determination of various biases that results to the pricing systems in Figure 4 is very uncertain in developing countries and has been discussed by Varangis and Larson (1996) and Dehn (2000). There are more predicted values at the highest price. The possible trends at different biases of prices are shown in Figure 4. However, the second perceptron has more effect than the first perceptron as shown in Figure 2 i.e. time of material order and current sales are more prevalent in construction projects in developing countries. Hence, the reputation of material manufacturer/supplier and the time of making order could determine the material pricing system.

Table 3 Validity of outcomes

Outcomes	N	Sum of Squares Error	Relative Error	Percent
Training	43	20.885	0.995	78.2%
Testing	12	1.483	0.909	21.8%
Valid	55			100.0%

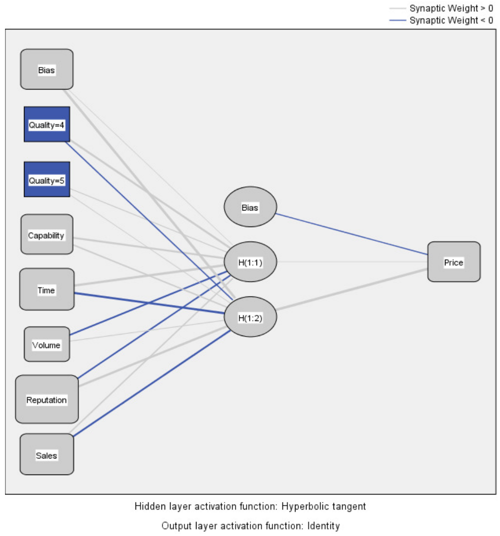

Figure 1 Neural outlook on material purchase

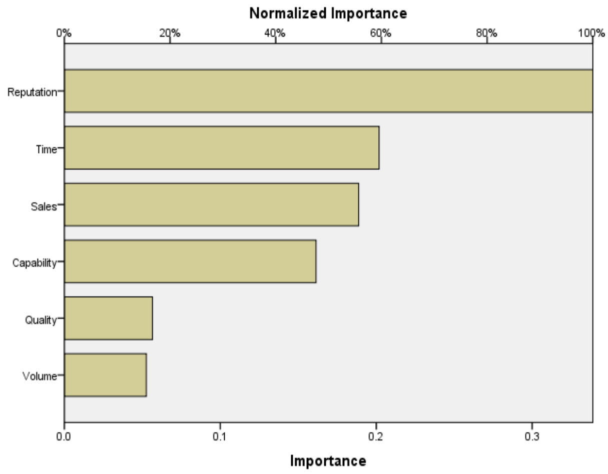

Figure 2 Important factors that initiates material purchase

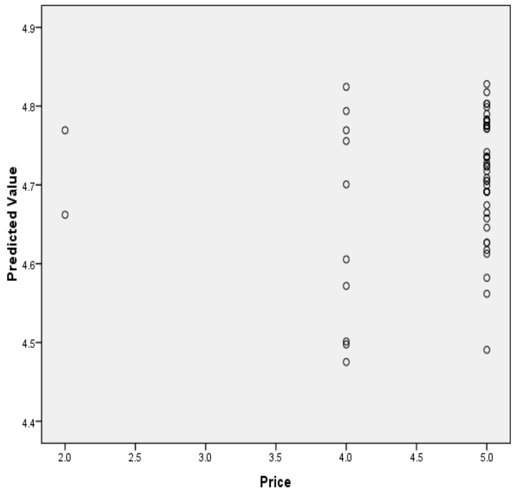

Figure 3 Price prediction

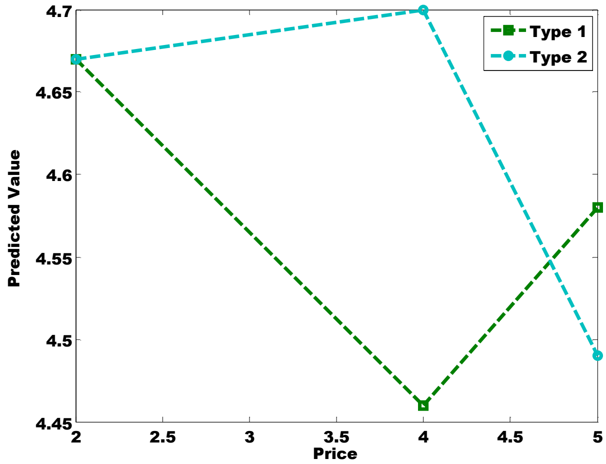

Figure 4 Types of pricing outcomes

6. CONCLUSIONS

The paper attempted to predict the factors affecting material procurement on construction sites. Volume of material ordered and reputation of manufacturers/suppliers were the strongest variables predicting material price while time of material ordered and current sales were found to predict the outcome of material quality. Moreover, material price during material procurement is unpredictable: appreciating at some times and crashing at other times. The study recommends the adoption of effective material procurement system that will bring about tradeoffs between material price, material quality and time of material order all of which are important in achieving construction project objectives.

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