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Logistics planning and management, a case study of the Nigerian postal service Ekpoma

Igbinoba JO[1], Odiamehi AM[2], Ugboya AP[3], Okoh F[4], Akele BO[5]
[1-5] Department of Industrial and Production Engineering, Ambrose Alli University Ekpoma, Edo State, Nigeria

Abstract
This research work presents an optimization-based model which deals with integrated logistics operational problem faced by the postal service in Ekpoma. The study employed both primary and secondary sources of data for analysis. A linear programming model was used to analyze the data collected and Mat lab optimization tool was also used optimizing the logistic channel in the post office. The result showed that due to the geographical location and some other constraints, such as the long distance between the post office warehouse and suppliers resulting in longer transit time, high logistic cost and Unequitable distribution of available transportation facilities are some of the methods recommended for the smooth operation in the post office.

Keywords: POS, Nomenclature

1. Introduction

Logistics is the procurement, maintenance, distribution, and replacement of personnel and materials, it is also the science of planning and implementing the acquisition and use of the resources necessary to sustain the operation of a system (Malik, 2010).

According to Johnson *et al.*, (2009) [10]. Logistics is generally the detailed organization and implementation of a complex operation. The resources managed in logistics can include physical items such as food, materials, animals, equipment, and liquids; as well as abstract items, such as time and information. The logistics of physical items usually involves the integration of information flow, material handling, production, packaging, inventory, transportation, warehousing, and often security (Cozzolino, 2011) [4]. The Oxford English Dictionary (2011) defines logistics as "the branch of science relating to procuring, maintaining and transporting material, personnel and facilities". However, the New Oxford American Dictionary (2012) defines logistics as the detailed coordination of a complex operation involving many people, facilities, or supplies and the Oxford Dictionary on-line defines it as the detailed organization and implementation of a complex operation". As such, logistics is commonly seen as a branch of engineering that creates "people systems" rather than "machine systems.

Logistics planning and management is the part of supply chain management that plans, implements, and controls the efficient, effective forward, and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customer's requirements. The logistics planning and management services pathway includes occupations which involve the planning, management and control of the physical distribution of materials, products, and people. The complexity of logistics can be modeled, analyzed, visualized, and optimized by dedicated simulation software. The minimization of the use of resources is a common motivation in all logistics fields. A professional working in the field of logistics management is called a logistician.

Postal service plays a significant role in the development as a leading commercial and financial region, providing communications between individuals, business and government. In recent years, postal operators are faced with the challenges of rapid technological development, market liberalization, and segmentation and increasing competition. In such conditions, the industry has evolved to include traditional post (like package and mail delivery), courier services, freight services and e-services and leading European postal operators (such as: Deutsche Post DHL, La Poste i Royal Mail) have expanded their operations in the logistics sector.

1.1 Statement of the problem

In the outbound logistics, the demand and flow of materials and resources is deteriorating because of numerous reasons among which are poor equipment's, handling, inadequate maintenance, poor planning and management bad state of access road etc. which in turn slows down the materials delivery service of the postal service.

1.2 Aim of the study

The aim of this work is to attempt to enhance logistics planning and management in Postal service.

1.3 Objectives of the study

- To examine logistics control system in the post office
- To formulate a Logistics Model for logistics management
- To make recommendations that will improve efficiency in the management of logistics in the post office

1.4 Significance of the study

This study will be of significant benefit to logistics firms the government at all levels, manufacturing firm's as well as researchers.

1.5 Scope of the study

This study focuses on the logistics planning and management in Ekpoma Postal service.

1.6 Literature review

Ozdamar *et al*., (2004) developed a network flow model to implement on logistics planning in emergency situations. The model deals with the transportation problem that occurs in the event of natural disasters. Problems occur due to the time-aspect involved in rescue efforts. Supply available only in limited quantities poses also a major issue. They develop a mathematical model that addresses the dynamic time-dependent transportation problem that needs to be solved repetitively at given time intervals during on-going aid delivery. Model outputs are dispatch orders for vehicles waiting at different locations in the area. These orders designate the routes of vehicles including empty trips, pick-ups and deliveries in mixed order and waiting interludes throughout the planning horizon. The model takes into consideration time-dependent supply/demand and fleet size, and facilitates schedule updates in a dynamic decision-making environment. The authors implemented the model in a realistic scenario based on the attrition figures of the 1999 Izmit earthquake in Turkey.

De Angelis *et al*., (2007) developed a multi-period routing and scheduling model for transporting humanitarian food aid via cargo air planes. Their model minimizes total unsatisfied demand and although it includes constraints that may not lead to equitable solutions such as all beneficiaries receive a minimum amount of goods, it can be used to enforce minimum standards. In general, for rapid and early response maximizing total speed of delivery while delivering the maximum quantity of goods possible is essential. Equality in delivery is more suited to longer-term recovery and development aid where speed is less of a factor to worry about (De Angelis *et al*. 2007).

Earky, (1977) and Wu Shinong (2003) selected all seventy ST companies that were treated specially between 1998 and 2000 in China A-share market and the same amount non-ST companies as the matching sample, then used cross-section analysis, univariate analysis, linear probability model, Fisher two-groups linear discriminant analysis, Logit models and other statistical methods to predict the financial difficulties of the company. His paper pointed that prediction accuracy rate of Logit model was 93.53%.

WU (2003) Liang Qi (2005), taking into account high-dimensional and high correlation of the financial data of listed companies, used principal component analysis to reduce the dimensions of data, and modified the Logistic regression equation by using the components as dependent variables. The results showed that the accuracy rate of classification and prediction for business failure through the modified model were higher than that through the simple Logistic regression analysis.

Fawcett at al. (2000) present a simulation model where using as input the numbers of locations of casualties rescued alive, the scale of pre-hospital care, the post-earthquake hospital capacity and the transport system they model the movement of the casualties. The model predicts the number of casualties that die during that movement and makes some prediction about the health-care system response, e.g. waiting time before treatment. The mathematical model can be used for planning and training.

It is well documented that mortality rates increase with proximity to the epicentre of an earthquake and with increasing earthquake magnitude. Seismic intensity has been identified as the primary cause of mortality and injury during earthquakes, mediated by building damage (Aleskerov *et al*. 2005). Studies about the role of socio-demographic factors on earthquake vulnerability are rare

(Badal *et al*. 2005). In a combined concept using a house hold survey and observational damage assessment, social and environmental determinants for injury and displacement were investigated by Milch *et al*. (2012) and statistical modelling approaches were used to explore to what extend seismic intensity, distance to rapture, living conditions and educational attainment affect displacement and injury rates (Milch *et al*. 2010).

The results showed that about 55% of the variability in displacement rates could be explained by the above factors. Living conditions were a strong predictor of injury and displacement, indicating a strong association between risk and socioeconomic factors.

Mathematical modelling and decision support systems can also be used for the management of medical supplies such as blood, vaccine or drug supplies during a pandemic (Kamp *et al*. 2010, Shrestha *et al*. 2010, Lin *et al*. 2012). During an influenza pandemic, optimal dosing and dynamic distribution of vaccines is essential. Given the limited production capacity and delays in vaccine development during a pandemic, the production of antigen-sparing vaccines that allows an increased population coverage but being less efficacious is a reasonable option. The trade-off between the two effects was studied by Wood *et al* (2009).

The 2009 H1N1 influenza A pandemic represents a typical example where many public health decisions on how to mitigate the pandemic had to be made quickly and were associate not only with the public health component of the issue but also with the corresponding economics. Vaccination was the dominant public health intervention during the pandemic. An assessment of the effectiveness and the cost-effectiveness of several vaccination strategies in real–time using a transmission dynamic model fitted to the estimated number of cases was performed (Baguelin *et al*. 2010). The model was employed to generate plausible scenarios under different vaccination strategies. The proportion of these cases by age and risk group resulting in practitioner consultations, emergency rooms visits, hospitalizations, intensive care and death was estimated using existing data from the pandemic.

Baker *et al*. (2011) used Statistical packages such as FluSurge (developed by the Centers for Disease Control and Prevention in the USA) were used for the same pandemic to estimate the potential surge in demand for hospital-based services (Baker *et al*. 2011). The modelling tool predicts the surge in demand during an influenza pandemic yielding estimates of the number of hospitalizations and ICU admissions and deaths caused by a pandemic compared to the existing hospital capacity. Based on a web-based survey, the feedback of the model was evaluated to be positive and useful to service planning for local hospitals.

(Hufnagel *et al*. 2004). measures them in a systematic and precise manner, it is designed to develop a logistic model for Nigeria postal service, Ekpoma

2.1. Area of study

This study was conducted in Nigeria postal service Ekpoma. a small town in the southwest part of Edo state in southern

Nigeria, because of the fact that its houses one the oldest state owned university the flow of mails and logistical items is common site.

2.2. Research design

Descriptive survey was adopted for this study because of its fact-finding nature. The research will be structure as follows. First will be to collect data and analyses it with the model. Data collection was done principally in two phase first was to a minister prepared questionnaires' relevant for analysis to staff customers and other relevant stakeholders in postal industry Result was discussed before recommendations based on the outcome of study.

2.3. Data collection

Both primary and secondary data collection techniques were used in the research in order to get quantitative and qualitative information for analysis. Working process observation and interview with the staffs and management was done to gain accurate primary data. Moreover, historical data such as supplier performance, standard working procedure, supplier evaluation, were also obtained as the secondary data., the quantitative data from the existing working spreadsheets and the post office mail distribution system were accessed and collected.

2.4 Method of data analysis

After collecting all the necessary data, these data were edited and arranged in Tables to eliminate errors and ensure consistency. The model was developed using liner programming and Transportation problem. Data was entered into the computer Program called MATLAB. Data collected on their logistics, such as post types, demand of post type, Delivery and the transportation pattern and challenges in the post office. The models ware developed based on the supply chain management theory in order to achieve the lowest cost, responsiveness and shared objectives, delivery planning optimization models, and transportation pattern, are formulated.

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Table 3.7.1

Resource	Resource Usage per Unit of Activity				Amount of Resource Available
	Activity				
	1	2	…	n	
1	a_{11}	a_{12}	…	a_{1n}	b_1
2	a_{21}	a_{22}	…	a_{2n}	b_2
.					.
.	…	…	…	…	.
.					.
m	a_{m1}	a_{m2}	…	a_{mn}	b_m
Contribution to Z per unit of activity	c_1	c_2	…	c_m	

In summary, the standard form of maximizing profit can be expressed as follow.

Maximize $Z=c_1x_1+c_2x_2+\cdots+c_nx_n$

Subject to the restrictions

$a_{11}x1+a_{12}x_2+\cdots+a_{1n}x_n\leq b_1$

$a_{21}x_1+a_{22}x_2+\cdots+a_{2n}x_n\leq b_2$...

$a_{m1}x_1+a_{m2}x_2+\cdots+a_{mn}x_n\leq b_m$

and

$x1\geq 0,2\geq 0,\ldots,xn\geq 0$

In contrary, the minimizing cost formulation can be shown as follow.

1. The objective function:

Minimize $Z=c_1x_1+c_2x_2+\cdots+c_nx_n$

2. The constraints are in inequalities:

$a_{i1}x_1+a_{i2}x_2+\cdots+a_{in}x_n\geq b_i$ for some values of i

3. Or some functional constraints are in equation form

$a_{i1}x1+a_{i2}x_2+\cdots+a_{in}x_n=b_i$ for some values of i

4. Define the value of decisions variables:

x_j unrestricted in sign for some values of j

2.7. Logistics optimization

The principle of optimization is minimizing or maximizing a quantifiable objective function by changing values of a set of quantifiable constraints. In logistics aspect, optimization is used for several purposes such as minimizing total cost and maximizing utilization, e.g., Frazelle expressed that the customer service policy objective is to minimizing the total logistics costs (TLC) [16]. The constraints are inventory carrying costs, response time costs, and lost sales costs. A mathematical equation can be written as follows; *Minimize*:

Total logistics costs = Inventory carrying costs + Response time costs + Unforeseen cost.

Constraints

1. Inventory availability > Customer service inventory target
2. Response time < Customer service response time target

The customer service optimization, from the above expressions, is a kind of tradeoff activity, e.g., if the inventory level is high, the inventory carrying cost increases, the lost sales cost will have to be reduced. On the other hand, if the management intends to reduce the lost sales cost by reducing response time; consequently, the transport cost or warehousing cost will be higher.

2.8 Mathematical model formulation

For the given problem, we formulate a mathematical description called a mathematical model to represent the situation. The model consists of following components:

Decision variables: These variables represent unknown quantities (number of items to produce, amounts of money to invest in and so on).

Objective function: The objective of the problem is expressed as a mathematical expression in decision variables. The objective may be maximizing the profit, minimizing the cost, distance, time, etc.

Constraints: The limitations or requirements of the problem are expressed as inequalities or equations in decision variables. Followings are the decision variables, objective function and constraints specific to the problem of this study:

Table 3.1: Summary of data from questionnaire

Post type	Rate of demand	Delivery time	Bottlenecks	Transportation facilites
Ordinary Posting	50	6 days	Transportation cost	1
Registered mail posting	30	4 days	Transportation cost	1
Courier service posting	20	7 days	Transportation cost	1

***Source*:** Field survey, 2017.

2.9 Transportation Optimization

The general objective of transport optimization is minimizing transport cost subjected to the customer service policy. Normally, the transport solution affects inventory carrying and warehousing cost considerably; thus, they should be included in the objective function to express the influence by transport solution directly. From an example of Frazelle (2001), response time requirement, time windows, volume requirements, frequency of use should exist in the objective function of transport optimization while constraints are lane capacities, vehicle capacities, container capacities, workforce capacities, and workload imbalances. Nonetheless, this example is merely a guideline to determine an optimal transport solution which must be adjusted according to relevant condition in the camp.

2.10 Transportation algorithm

The algorithm for solving to a transportation problem may be summarized into the following steps:

Step 1: Formulate the problem and arrange the data in the matrix form: The formulation of the transportation problem is similar to the Linear Programming formulation. Here the objective function is the total transportation cost and the constraints are the supply and demand available at each source and destination respectively.

Step 2: Obtain an initial basic feasible solution: In this chapter, the following two different methods are discussed to obtain an initial solution:

- North – West Corner Method
- The Least Cost method

The initial solution obtained by any of the two methods must satisfy all the supply the following conditions:

1. The solution must be feasible, i.e. it must satisfy all the supply and demand constraints.
2. The number of positive allocations must be equal to $m + n - 1$, when m is the number of rows and n is the number of columns.

Any solution that satisfies the above conditions is called *non-degenerate basic feasible solution*.

Step 3: Test the initial solution for optimality: In this chapter, the *Corner – West Corner Method* is discussed to test the optimality of the solution obtained in step 2. If the current solution is optimal, then stop. Otherwise, determine a new improved solution.

Step 4: Updating the solution: Repeat step 3 until an optimal solution is reached.

The transportation problem is concerned with finding the minimum cost of transportation of a single commodity from a given number of sources (e.g. factories) to a given number of destinations (e.g. warehouses). These types of problems can be solved by general network methods, but here we use a specific transportation algorithm. The data of the model include:

1. The level of supply at each source and the amount of demand at each destination.
2. The unit transportation cost of the commodity from each source to each destination.
3. Since there is only one commodity, a destination can receive its demand from more than one source. The objective is to determine how much should be shipped from each source to each destination so as to minimize the total transportation cost.

Destination

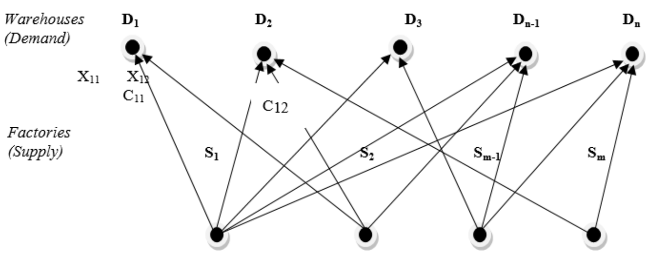

Fig 1

This figure represents a transportation model with *m* sources and *n* destinations. Each source or destination is represented by a node. The route between a source and destination is represented by an arc joining the two nodes. The amount of supply available at source *i* is S_i, and the demand required at destination *j* is *Dj*. The cost of transporting one unit between source *i* and destination *j* is c_{ij}.

Let x_{ij} denote the quantity transported from source *i* to destination *j*. The cost associated with this movement is cost quantity = $c_{ij}x_{ij}$. The cost of transporting the commodity from source *i* to all destinations is given by

$$\sum_{j=1}^{n} c_{ij}x_{ij} = c_{i1}x_{i1} + c_{i2}x_{i2} + \dots + c_{in}x_{in}$$

Thus, the total cost of transporting the commodity from all the sources to all the destinations is

Total Cost =

$$\sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}x_{ij}$$

$$= c_{11}x_{11} + c_{12}x_{12} + \dots + c_{1n}x_{1n} + c_{21}x_{21} + c_{22}x_{22} + \dots + c_{2n}x_{2n} + c_{m1}x_{m1} + c_{m2}x_{m2} + \dots + c_{mn}x_{mn}$$

In order to minimize the transportation costs, the following problem must be solved:

$$\text{Minimize } z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}x_{ij}$$

Subject to

$$\sum_{j=1}^{n} x_{ij} \le d_i \text{ for } i = 1, \dots, m$$

and

$$\sum_{i=1}^{m} x_{ij} \ge s_i \text{ for } j = 1, \dots, n$$

Where $x_{ij} \ge 0$ for all *i* and *j*

The first constraint says that the sum of all shipments from a source cannot exceed the available supply. The second constraint specifies that the sum of all shipments to a destination must be at least as large as the demand. The above implies that the total supply

$$\sum_{i=1}^{m} d_i$$

is greater than or equal to the total demand

$$\sum_{j=1}^{n} s_j$$

when the total supply is **equal** to the total demand (i.e.

$$\sum_{i=1}^{m} d_i = \sum_{j=1}^{n} s_i$$

Then the transportation model is said to be **balanced**. In a balanced transportation model, each of the constraints is an equation:

$$\sum_{j=1}^{n} x_{ij} = d_i \text{ for } i = 1, \dots, m$$

$$\sum_{i=1}^{m} x_{ij} = s_i \text{ for } j = 1, \dots, n$$

A transportation model in which the total supply and total demand are unequal is called unbalanced. It is always possible to balance an unbalanced transportation problem.

Example 1 Balanced transportation model.

Consider the following problem with 2 factories and 3 warehouses:

	Warehouse 1	Warehouse 2	Warehouse 3	Supply
Factory 1	C_{11}	C_{12}	C_{13}	20
Factory 2	C_{21}	C_{22}	C_{23}	10
Demand	7	10	13	

Total supply = 20 + 10 = 30

Total demand = 7 + 10 + 13 = 30

Since Total supply = Total demand, the problem is balanced.

3. Presentation of data

The first step is to organize the tableau to represent the model. Once the model is implemented in a spreadsheet, next step is to use the optimization tool to find the optimum transportation cost. In the formulation of the models, we need to identify the locations (cells) of objective function, decision variables, nature of the objective function (minimize) and constraints. The data for this study are in the table I below which were extracted from the logistics record of *Nigeria postal service Ekpoma.*

3.10. Modeling of transportation cost of logistics in post office

Table 4.2.1: Average transportation costs of each logistics

Distributor's Warehouse/Post office Warehouse	Warehouse 1	Warehouse 2	Warehouse 3	stock
Distributor 1	15	160	100	1168
Distributor 2	160	12	260	1560
Distributor 3	154	315	56	1439
Distributor 4	245	410	190	986
Distributor 5	130	290	58	1658
Distributor 6	125	427	204	2035
Distributor 7	215	375	160	1159
Cost	3980	1785	4856	

We model by identifying the relevant variables and expressing the objective and constraints of the problem in terms of the variables.

Objective Function =

Maximize $Z = 3890x_1 + 1785x_2 + 4856x_3$ ……………………………………………..eqn 1

Constraints

Subject to

$15x_1 + 160x_2 + 100x_3 \geq 1168$

$160x_1 + 12x_2 + 260x_3 \geq 1560$

$154x_1 + 315x_2 + 56x_3 \geq 1439$

$245x_1 + 410x_2 + 190x_3 \geq 986$

$130x_1 + 290x_2 + 58x_3 \geq 1658$

$125x_1 + 427x_2 + 204x_3 \geq 2035$

$215x_1 + 375x_2 + 160x_3 \geq 1159$

$x_1, x_2, x_3 \geq 0$

3.11 Solution of our model in Matlab

```
>> F=-[3890;1785;4856];
>> A=[15 160 100;160 12 260;154 315 56;245 410 190;130 290 58;125 427 204; 215 375 160];
>> B=[1168;1560;1439;986;1658;2035;1159];
>> Aeq =[ ]
>> beq =[ ]
>>Lb=[0;0;0]
>>ub=[]
>> [x fval]=linprog (F, A, B, Aeq, beq, Lb, ub)
```

Result of our model in Matlab optimization tool box

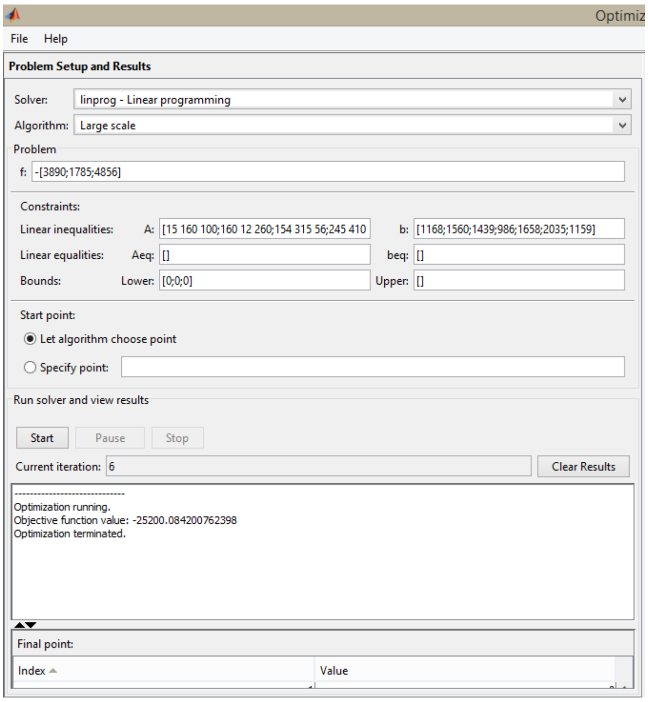

Fig 4.4.1: Showing matlab optimization tool box result

Total maximization cost is N 25200. 08 to transport mails from the post office warehouse to the recipient's destinations.

3.12 Discussion of result

The various estimated values of the optimization model for Logistics transportation are presented in the model above. We introduced a slack or surplus variable in order to bring the problem into standard form after converting the problem into maximization problem. From our result above which gave -25200. 08 it shows that there are a lot of constraints and limitations associated with transportation in the firm. The customer service optimization, from the above expressions, is a kind of tradeoff activity meaning if the inventory level is high, the inventory carrying cost increases, the lost sales cost will have to be reduced. On the other hand, if the management of the establishment intends to reduce the lost sales cost by reducing response time; consequently, the transport cost or warehousing cost will be higher therefore adequate transport facilities such as buses and motorcycles should be made available in the post office. Also sub-branches with different representatives having delivery men should be in different districts to aid fast and accurate distribution of mails.

The delivery performance is mostly measured in 4 aspects, delivery time, cost, utilization, and quality. Although these 4 measurements are the shared objectives of every function in the supply chain the decision made in each process can either support each other or conflict to one another.

Therefore, the optimization has to be done not only for each function, but also for the integrated supply chain functions. Normally, the on time delivery is the major criterion used to select the model. Like customers in other business, the company's customers require that besides the desired quality, the customers also want the cost-efficient product delivery, with quick response and short lead time. These requirements pass on the pressure to the supply chain and logistics department to perform the excellent operations to meet the 4 major logistics performance target which are the low cost, short lead time, good quality and high utilization. The minimum order quantity and the other agreements such as the slitting and loading pattern have the significant consequence on the logistics planning and logistics cost. Due to some of the geographical constraint, the long distance between the post office and customers caused long transit time and high logistics cost. inefficient planning may also cause low logistics utilization, high delivery cost, or high inventory of excess stock. On the other hand, the decision making in other functions such as the container size selected, minimum order quantity, and loading agreement made with supplier also bring difficulties to the delivery planning and cause the inevitable cost

3.13. Conclusion

This work is concerned with developing a logistics model to assist decision makers in postal service Ekpoma branch in their inventory/transportation system. The integration of Linear programming optimal control of the combined inventory and transportation system provides the foundation for the decision support system. After studying a wide spectrum of both linear and integer programming's methods, the transportation model was chosen and modified to fit the needs of the study.

The optimization model was formulated in a consistent and interactive manner so that the insight and results obtained can be utilized to validate and improve the current process.

This study proves that significant savings can be made by optimizing logistics in post office, Ekpoma and this can be ensured by proper planning and scheduling of task as well as providing adequate transportation facilities as it seems to be the major bottleneck in the firm Operations. Therefore, the setting of these parameters was arranged in order to gain the systems optimization. The performance measurements differ even though most of them can be translated to the quantitative measurement, different performance aspect has different units which cannot be compared directly. For instance, the delivery time aspect can be measured with the transit time used for the delivery whereas the delivery cost is shown in term of money, while utilization is measured in percentage of utilization or waste. Consequently, some decisions were made just by estimation. In order to be able to compare several aspects, the conversion to the same unit is needed. Hence, the logistics optimization is a matter of balancing the conflicting goals in the most efficient way.

This new approach will be expected to ensure optimal solution and increase the transparency of the decision making if it is used as the standard procedure. Generally, the optimization tools in this study are developed with the intention to optimize the overall logistics cost including the intangible costs. Furthermore, desired objectives have been considered and converted into costs for comparison and all related information from every function in the supply chain has been shared to create the process alignment and gain better communications which are the important characteristics of the responsive supply chain.

3.1 Recommendation

Arising from our results, we recommend the following for optimal performance in the post office

1. Other models to optimize the queuing system in the post office should be measured in further study
2. For effective flow of logistics in the post office warehouse, there should be an equitable distribution of tasks across all staffs
3. Other methods of transportation such as Helicopter should be utilized for fast deliveries of logistics in the post office.

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