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Analysis of Vehicle Routine and Scheduling (VRS) Cost in Total Logistics Cost of Manufacturing Companies in Southwestern Nigeria

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Abstract

The importance of VRS in logistics activities of manufacturing companies are well appreciated but need not be over flogged, but rather how this salient issue in Transportation can be more practicable among manufacturing companies. It is in this light that the paper examines and modeled VRS within the context of Total Logistics cost with a view to minimizing cost and enhance effective distribution activities in manufacturing companies. The paper adopted case study approach. Forty-five (45) manufacturing companies formed the sample of the study, based on multi stage sampling techniques that incorporated cluster, stratified and purposive sampling methods. Various VRS components-Labour cost; Transport cost; Maintenance cost, Information cost and others were identified and analysed using adapted distribution function of Cobb-Douglas that incorporates Ordinary Least Square and Weighted Least Square methods. All these components were regressed on the Volume/Quantity of goods distributed. Similarly, translog cost function equally revealed that the parameters in the constrained model are significant, consequently explained a large part of the variation in the data set. The paper recommends that companies should adopt scientific information management system that is information technology in orientation, which will in turn propel VRS as well as lay emphasis on IT investment in attempt to cut cost, simultaneously maintaining customers' service.

Key Words: *Analysis, Vehicle, Routine, Scheduling, Cost, Logistics.*

Introduction

According to Gottorna (1997), customer and consumers have become more conscious of their power in competitive markets. The suppliers' retort was bespoke services to meet specific customer expectations. This on the other hand requires a more integrated and coordinated approach to react to the ever changing environment and to be able to react quicker. Suppliers are now working together to obtain lower logistics and supply chain costs and to offer value-added services in an attempt to gain competitive market advantage. According to Gattorna (1997), this has led to the fact that the supply chain has become more intricate and in particular, the transport activity. The author further stipulates that suppliers have taken a number of initiatives designed to reduce logistics supply chain inventories. The direct results of this were increased transport costs. The initiatives include; continuous replenishment, cross-docking, selective sourcing and postponement. This will enable total logistics optimisation rather than just transport optimization.

Similarly, Milligan (2000), states that "with most supply chain activities, about 80% of the cost is going to be transportation, while about 20% will cover the cost of warehousing and cross-dock activities". Milligan stipulates further that transport tends to be monotonous and that the activity is not the main budget item in most companies. Managers view the transportation activity as something that is not of the greatest importance and that nobody is concerned about it until the costs start escalating (Milligan, 1999).Ironically, the traditional methods used by shippers to counter inevitable increases in transportation costs are competitive bidding, optimization of networks, redesign of networks and a repetition of the previous steps (Brandy, 2000). These methods involve network, lane and node decision –making that are not within the ambit of this paper. However, Brandy (2000), is of the opinion that great saving can be made in the area of critical logistics planning of outbound transportation, inventory management, production planning, warehousing distribution and purchasing are needed to reduce static inventory. Above all, "The emergence of new objectives for the transportation function has created the need for, a framework that identifies and organize transportation decision making in an integrated supply chain environment" (Stank, et al ,2005).

Of importance is the customer service that is described as 'fuel that drives the logistics supply chain engine' (Coyle, et al, 1996). The core principle is to have the right product to the right customer in the correct quantity, without any damage. However, at the end of the 1980s the focus was shifted from cost reduction to improvements in customer service. Improving on supply chain performances led to improvements in revenue growth and higher profitability through the gaining of market share. During this time the focus of reducing supply chain assets and total costs in the supply chain slowed remarkably (Davis and Drumm, 1996). Transport and the efficiency thereof will have a major impact on both cost reduction and customer service, both from an outbound and inbound distribution point of view (Coyle, et al 1996).However, all these would not have been achieved, but adequate VRS. This on one hand has been constrained with problems that revolve around the design of routes for delivery vehicles in physical distribution that operate from a single depot and supply a set of customers at known locations with known demand. Routes for the vehicles are usually designed to minimize the total distance traveled or a related cost function (Cacceta et al, 2003)

Scheduling on the other hand involves timing and coordination (reduced delivery time, energy cost and vehicle wears). Vehicle scheduling problems can be thought of as routing problems with additional constraints imposed by time periods during which various activities may be carried out. Three constraints commonly determine the complexity of the vehicle scheduling problems. The length of the time that a vehicle may be in operation before it must return to the depot for service or refueling; the fact that certain tasks can only be carried out by certain vehicle types; and the presence of a number of depots where vehicle may be housed (Huan, 1995). Thus, Vehicle Routing and Scheduling is critical in successful logistics execution since it is one of the most important components of downstream logistics activities (Giaglis etal,2003).In the past, attention has focused mainly in optimally allocating vehicles to a known delivery demand under prior assumed conditions.

Conversely, limited research has to date been devoted to the real time management of vehicles during the actual execution of the distribution schedule in order to respond to unforeseen events that often occur and may deteriorate the effectiveness of the predefined and static routing decisions. Such events that create a dynamically changing problem state includes: traffic conditions, vehicle –related incidents (for example, breakdowns), market triggered events (for example, changing customer orders or delivery times) and so on, and ironically, little attention has been placed on the inherent cost of VRS. Interestingly, the most common Vehicle Routing and Scheduling problem objective is to minimize total cost of deliveries, additional benefits might be minimizing number of depots or maximizing customer satisfaction (Cacceta et al, 2003).

Cost Drivers in Vehicle Routine and Scheduling Activities:

In view of the above, it is pertinent to highlight some examples of cost drivers in the VRS activity centre, with a view to giving an idea about what cost driver could be, relatively to pricing in distribution activities.. Examples of cost drivers related to downstream logistics activities are:

- Volume of goods carried
- Transportation cost
- Weight of goods carried

- Distance over which the goods are carried
- Information cost
- Labour cost
- IT investment cost
- Number of deliveries
- Service cost
- Maintenance cost

It is pertinent to stress that attention will be focused on this part of the cost driver, because of the uniqueness of the variables, but that does not undermine market-related variables, but because of external influence like governmental policy and socio-political factors which will affect adequate and accurate data needed to be calibrated in the model. Above all, the former cost drivers are the major thresholds in which the market-related factors depend upon. In a related manner, Manufacturers face complex problem of determining the optimal number, capacity and location of facilities serving more than one customer and finding the optimal set of vehicle schedules and routes (Giaglis et al, 2003).Such problem arises from many physical systems dealing with distribution. This specific problem which arises depends upon the type of constraints and management objectives. The constraints of the problem arise from the vehicle capacity, distance time restrictions, numbers of customers serviced by a vehicle and other practical requirements. The management objectives usually relates to minimization of cost/ distance or fleet size (Cacceta et al, 2003)

Methodology/Study Area

Study Area

South-Western part of Nigeria lies between latitude 60N and 8½0N of the equator and longitude 30E and 50E of Greenwich Meridian Time (GMT).The zone consists of Six States. These are Lagos State that stretches along the seaboard, Ogun, Oyo, Osun, Ondo and Ekiti State. The South-Western Geopolitical Zone occupies an area of 79,048 Square Kilometres. The Zone covers about one-twelfth of Nigeria, and into it are packed almost 25 million or about one-fifth of the entire population of the Country. The area is washed in the South by the Gulf of Guinea. On the east it is bounded by South-Eastern Nigeria. On the West, it shares a common frontier with the Republic of Benin; and on the north, it is bounded by North Central Geo-Political Zone that consists of Kwara State, Kogi State, Niger State and others. The majority of the people in South-Western Nigeria are Yorubas, which occupies major urban centres of this Geo-political Zone (Somuyiwa, 2010a)

In a related development, major population concentration are found in the state capitals and other important towns in the region like Ikorodu, Epe and Badagry (Lagos state) ; Abeokuta, Ijebu ode,Ijebu Igbo, Shagamu, Ilaro, Ifo, Otta, and Aiyetoro (Ogun state); Ogbomoso, Iseyin, Oyo, Ibadan, Kishi, Igboho,and others (Oyo states). Other towns include Iwo, Gbongan, Ikire, Ifon, Ede, Ikirun, Ilesha and Oshogbo (Osun state); Owo, Ikare, Akure, Ondo, Okitipupa and Oka Akoko (Ondo state) and Ise Ekiti, Efon, Alaye and Ado Ekiti in Ekiti state.There have been considerable increase in the population figures of these states; for instance, Oyo state was estimated to be 3.5 millions in 1991 and 5 millions in 2005. Lagos was estimated to be 10 million in 2005, while Ogun state was estimated to be 3.5 million in 2005 population census (NPC, 2006). It is interesting to note that all these can be attributed to the economic activities, which targentially determine the rate of the distribution of these products (Somuyiwa, 2010a).

Methodology

Data set for this paper was sought from Forty-five (45) manufacturing companies that are within the ambit of Food, Beverage and Tobacco sectoral group, between the years of 2006 and 2010. The choice of this particular manufacturing group is predicated on its ubiquitous nature of these companies in the study area. Again, their products directly affect people's life such that they have socio-cultural implications, especially their rate of consumption. Above all, the sectoral group is one of the most quoted sectors at the stock market; consequently, accessibility to information about it was not problematic. Sequel to the above, model and equations were developed for the paper through Cobb-Douglas production function that is related to inbound logistics, but now adopted to outbound logistics, as presented thus

VRc = Transport cost + Information cost+ Number of Deliveries + Labour cost +Service cost + Maintenance cost + Distance at which goods are carried+IT investment + Weight of goods

Equation:

VRc = f(T F N L S M D I W) …………………………2.1

$Tc = \alpha + \beta_1(T) + \beta_2(F) + \beta_3(N) + \beta_4(L) + \beta_5(S) + \beta_6(M) + \beta_7(D) + \beta_8(I) + \beta_9(W)\ e$……………2.2

Where α = constant
VRc = Vol./Quantity of goods distributed
T = Weight of goods
F = Number of vehicle used
N = Number of Deliveries
L = Labour cost
S = Owned vehicle cost
M = Rented vehicle cost
D = Distance over which the goods are carried
I = IT investment
W= Weight of goods

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9$ are the associated output elasticities and e represents the error term.

Also for estimation purposes, the above function was linearized by taking logarithms of equation (2.1) and adding an error term.

This is done by using a system of five equations, one for each year:

$Log(Q_{01}) = {}_{01} + {}_{1}Log(T_{01}) + {}_{2}Log(F_{01}) + {}_{3}LogN_{01}) + {}_{4}Log(L_{01}) + {}_{5}Log(S_{01}) + {}_{6}Log(M_{01}) + {}_{7}Log(D_{01}) + {}_{8}Log(I_{01}) + {}_{9}Log(W_{01})_{01}$…. 2.3

$Log(Q_{02}) = {}_{02} + {}_{1}Log(T_{02}) + {}_{2}Log(F_{02}) + {}_{3}Log(N_{02}) + {}_{4}Log(L_{02}) + {}_{5}Log(S_{02}) + {}_{6}Log(M_{02}) + {}_{7}Log(D_{02}) + {}_{8}Log(I_{01}) + {}_{9}Log(W_{01})_{02}$ … 2.4

$Log(Q_{03}) = {}_{03} + {}_{1}Log(T_{03}) + {}_{2}Log(F_{03}) + {}_{3}Log(N_{03}) + {}_{4}Log(L_{03}) + {}_{5}Log(S_{03}) + {}_{6}Log(M_{03}) + {}_{7}Log(D_{03}) + {}_{8}Log(I_{01}) + {}_{9}Log(W_{01})_{03}$ … 2.5

$Log(Q_{04}) = {}_{04} + {}_{1}Log(T_{04}) + {}_{2}Log(F_{04}) + {}_{3}Log(N_{04}){}_{4}Log(L_{04}) + {}_{5}Log(S_{04}) + {}_{6}Log(M_{04}) + {}_{7}Log(D_{04}) + {}_{8}Log(I_{01}) + {}_{9}Log(W_{01})_{04}$ … 2.6

$Log(Q_{05}) = {}_{05} + {}_{1}Log(T_{05}) + {}_{2}Log(F_{05}) + {}_{3}Log(N_{05}) + {}_{4}Log(L_{05}) + {}_{5}Log(S_{05}) + {}_{6}Log(M_{05}) + {}_{4}Log(D_{05}) + {}_{8}Log(I_{01}) + {}_{9}Log(W_{01})_{05}$ … 2.7

Where T, F, N, L, S, M, D, I &W were defined in equation (2)

This model was used to determine the relationships among components of Vehicle Routine and Scheduling cost in overall logistics management.

Literature and Conceptual clarification

Econometric estimation of production and cost functions

The cost analysis of VRS in transport and logistics industries is an important task for various purposes, including commercial enterprise public service obligation, regulatory decisions, government policy decision-making, and economic research and so on. Most recent studies of cost structure and economies of scale have employed econometric specification that link the concepts of production and cost, and exploit the duality between them. Drawing on previous empirical work in related industries, researchers began to estimate cost functions with more general forms such as the Cobb-Douglas and transcendental logarithmic (or translog) models (Somuyiwa, 2010a, 2010d).

It is interesting to state that the functional form most favoured in the literature has been the translog cost function, primarily because it places no priori restriction on the elasticities of substitution between the various restrictions such as homoedasticity, homogeneity and unitary elasticities of substitutions (Berngt, 1991), and the desirability of their imposition on the production structure (Button and O'Donnell 1985). The translog functional form for a single output technology was introduced by Christensen, Jorgensen and Lau (1973); the multi-output case was defined by De Borger (1984) and Burgess (1974). Viton (1980, 1981), Wabes and Coles (1975), Colburn and Talley (1992), Pozdena and Merewitz (1978) were the pioneers to use translog for transport cost and /or demand modeling.

The functional form used in the first empirical papers on production function estimations in the port sector is the Cobb-Douglas function, which reads as follows:

$$Y = AL^{\alpha}K^{\beta}T^{\Upsilon} \qquad 3.1$$

$$Y > 0,\ K>0,\ L>0,\ T>0,\ \alpha \geq 0,\ \beta \geq 0,\ \Upsilon \geq 0.$$

Where Υ is the output, L is the labour factor, K is the capital factor, T is the technology level and A, α, β, and Υ are the constant parameters to be estimated α, β, and Υ represent product elasticities with relation to labour, capital and technology, respectively, i.e., each one indicates the relative share of the corresponding factor in the total product.

The Cobb-Douglas functional form, although easy to estimate, presents important limitations. This functional form has been widely used in the literature to evaluate scale effects, since the latter could be easily contrasted parametrically through function exponents. This function belongs to the homogenous functions group and, therefore, it restrains the way in which scale effects and elasticities of substitution take place. There are other functional forms which do not present these limitations. Thus, the Constant Elasticity of Substitution function (CES) is the natural extension of Cobb-Douglas function since it allows the elasticity of substitution to take values different from the unit. The following obvious step is to generate a function allowing the elasticity of substitution of change when the product or the proportion of productive factors used varies. The production function enabling these two generalizations is the translogarithmic function (Nervlove, 1963).

Therefore, based on the foregoing, it is clearly preferable to use functional forms which avoid restrictions imposed by the functional form itself-such as the so-called flexible functional forms – developed on the basis that they provide a good local approximation of a twice differentiable arbitrary function (Christensen, et al 1973)). Moreover, this allows empirical contrast of additional restrictions, such as homogeneity, homotheticity, separability, constant returns to scale and constant elasticities of substitution, directly from the data instead of them being imposed a prior (De Borger, 1984).

The translog function is a quadratic form where variables have been expressed in logarithms:

$$\text{In C} = \alpha_0 + \sum_{1}^{m} \alpha_1 y_1 + \sum_{i}^{n} \beta_i w_i + \frac{1}{2} \sum_{i}^{m} \sum_{j}^{m} \delta_{ij} y_i y_j + \frac{1}{2} \sum_{i}^{n} \sum_{j}^{n} \gamma_{ij} w_i w_j + \sum_{i}^{n} \sum_{j}^{m} p_{ij} y_i w_j \qquad 3.2$$

Where:

In= Logarithm

C= Total cost
Other parameters as initially explained.

It is interesting to note that flexible functional forms present advantages and drawbacks. Then, the selection between them depends on the policy issue and context at stake. One of the advantages of the quadratic function is that it is well defined for zero values so it allows consideration of those cases in which some output vector element is nil, i.e., it enables the analysis of economies of scope and incremental costs (Viton, 1992). On the contrary, the translog function does not allow zero values and then, it is not suitable for the study of economies of scope unless a proper output transformation is applied, such as a Box-Cox transformation, which has been incorporated in the hybrid version of the code written. This does not only provide a solution, it also enhances the interpretation of parameters.

On the other hand, there are two disadvantages generally mentioned about the quadratic function. The first is that it is not possible to ensure that linear homogeneity in prices is met. However, this condition can be imposed simply by normalizing cost function by one factor price (Viton 1981). The second is that the cost function is very strict as regards specification of fixed costs whose effect should be captured by a single parameter, α_i,. The problem with this is that, in fact, fixed costs may vary depending on which subset of total products group is being produced. In order to solve this issue and give the functional form the capacity to capture these differences in fixed costs that may arise among companies producing different groups of products, dummy variables, F_i, are introduced. The value of these variables is represented by the unit where there is some production of product i, or zero otherwise. This leads to the following flexible fixed costs quadratic function (Mayo, 1984)

$$\text{In C} = \alpha_0 + \sum_{1}^{m} \alpha_1 y_1 + \sum_{i} \alpha_i F_i + \sum_{i}^{n} \beta_i w_i + \frac{1}{2} \sum_{i}^{m} \sum_{j}^{m} \delta_{ij} y_i y_j + \frac{1}{2} \sum_{i}^{n} \sum_{j}^{n} \gamma_{ij} w_i w_j + \sum_{i}^{n} \sum_{j}^{m} p_{ij} y_i w_j \qquad 3.3$$

In contrast, the translog function's main advantage is that it allows the analysis of the underlying production structure, such as homogeneity, separability, economies of scale, etc. through relatively simple texts of an appropriate group of estimated parameters. Its first order coefficients at the approximation point are the cost-product elasticities calculated at this approximation point (usually the mean) in a manner such that their addition represents an estimation of the inverse of the degree of economics of the scale (Obeng, 1984).

The number of parameters to be estimated is larger in the quadratic function than in the translog (Caves et al, 1980) and this is so because the restraints imposed on the translog function to ensure it fulfills the conditions of homogeneity of degree one in factor prices.A flexible functional form commonly used in empirical analyses is the translogarithmic function, which can be considered as an expansion of second order in logarithms of the variables in Taylor series. Indeed, this is the approach followed by Kim and Sachis (1986) in their study of the port of Ashdod. They estimated a translog cost function from which can be calculated input demand elasticities, economies of scale, and output cost elasticities. The own-price elasticity estimates showed a strong inelastic response to prices for each vessel type for each year. The estimates of economies of scale for each vessel type for each year showed increasing return to scale. The cost elasticities associated with each output group for each vessel type showed an inelastic response of total cost to changes in Cargo handling.

The cost function represents the minimum cost of producing any given level of output and is expressed as a function of input prices and output. The existence of a well defined cost function is based on a set of assumptions concerning cost minimizing behaviour of the firms. Specifically, this set of assumptions includes the presumption that the level of output y produced by the firm is predetermined, that the input prices are fixed and exogenous, and that the firm chooses input quantities so as to minimize the cost of producing output y. therefore, corresponding to a production function that indicates the maximum output y given any combination of inputs, there is a dual cost function relating the minimum cost of producing a given level of output to the input prices and the level of output y. this dual cost function can be written as $C = C^*(r, y)$ where r is a vector of input prices. The advantages of a cost function approach relative to a production function approach were summarized by Binswanger (1974);

1. A cost function is linearly homogeneous in input prices regardless of the homogeneity properties of the production function, meaning that a doubling of all prices will double the cost but will not affect factor ratios;
2. A cost function uses input prices as independent variables rather than factor quantities, and thus managers make decisions on factor use according to exogenous prices;
3. In production function estimation, input quantities tend not to be independent of one another leading to a possible problem of multicollinearity. Since there is usually little multicollinearity among input prices, this problem does not arise in cost function estimation.

Cobb-Douglas Cost Functions

In the short run then, the firm's expenditures on operations can be described by the following equation:

$$E = P_L L + P_F F + P_M M \qquad 3.4$$

Where E represents expenditures, and P_L, P_F, and P_M represent input prices for labour, equipment, and other resources, respectively. If we assume that the firm's production of an output (y) is described by Cobb-Douglas technology,

$$y = AL^a F^b M^c \qquad 3.5$$

The Cobb-Douglas cost function has a couple of notable properties. First, it allows for non-constant returns to scale, which makes it useful for testing the scale economies hypothesis. Also it allows for input substitutability, a feature not possible with more restrictive forms of production technology (McCarthy 2001).

The Translog cost Function

While the Cobb-Douglas functional forms could be employed to answer fairly straightforward questions about the cost and production of transport and logistics activities, they also entailed some important restrictions that limited their applicability. As noted previously, Cobb-Douglas cost function, for instance, allows for non-constant returns to scale and input substitution, the structure of these cost functions restrict substitution elasticities to unity and assume constant.

In order to relax these restrictions, econometric researchers developed various types of "flexible" cost functions, which were considerably more general than the one described above. Their flexibility derived from the fact that they place no priori restrictions on input substitution or returns to scale (McCarthy 2001). One particularly popular flexible functional form, the transcendental logarithmic (or "translog") specification, was introduced by Christensen, Jorgenson and Lau (1973). The translog cost function represented a second-order Taylor series approximation to an arbitrary cost function about its mean value. This specification allows for non-linear effect in each of the input factors, as well as interactions between input factors in the cost function, represented by quadratic and cross-product terms in the cost function (Berndt 1991).

The Duality of the cost Function

The importance of the dual approach, as stated by Beattie and Taylor (1985), resides in the fact that it “allows one to obtain product supply and factor demand equations, by partial differentiation of an indirect objective function”. Two important concepts are associated with duality. One concept is that of an indirect cost function, which is defined as the minimum cost of producing a specified output y, at given factor prices. That is

$$C = C^*(r, y), \tag{3.6}$$

Where r is a vector of input prices.

The properties of this indirect cost function have been summarized by (Chambers 1988):

1. Nonnegativity: if r > 0 and y > 0, then C* (r, y) > 0.
2. Nondecreasing in r: if r’ > r, then C*(r’, y) > C*(r, y). This indicates that increasing any input price must not decrease the cost.
3. Homogenous of degree one Inr: C*(tr, y) =tC*(r, y), since factor demand functions are homogeneous of degree 0 in r. So, as long as input prices only vary proportionately, the cost minimizing choice of inputs will not vary, but we would expect cost C* to vary proportionately.
4. Concave and continuous Inr.
5. Nondecreasing in y: if y > y’, then C*(r, y) > C* (r, y’)

Comparative Statics of the Cost Function

The questions addressed in this section are “How do cost and input demands respond to changes in input prices?” and “What happens to input utilization and cost if output increases?” To some extent, the first question was addressed in the earlier discussion of the cost minimization problem where it was shown that the responses of demand to input prices are computed from the Hessian matrix of the cost function, resulting in

$$\frac{\partial x_1^*}{\partial r_1} \leq 0 \tag{3.7}$$

$$\frac{\partial x_1^*}{\partial r_1} = \frac{\partial x^*_1}{\partial r_1}$$

Multiproduct Cost Concepts

An important component of the multiproduct cost structure is economies of scope. If economies of scope exist then cost savings may be obtained by simultaneously producing several different outputs in a single multiproduct company, instead of producing each output by its own specialized firm. The condition for economies of scope (Baumol, Panzar, and Willig 1988, Akridge and Hertel 1986) is

$$\sum_i C\ (y_i) > C\ (y), \tag{3.8}$$

Where y_i are output vectors and y is an output vector containing all of the y_i vectors. Therefore, economies of scope exist if the total cost of the joint output of all products is less than the sum of the costs of producing the products separately. Dividing the equation (3.8), C (y) provides a measure of the degree of economies of scope, where economies of scope exist if EOS > 0:

$$EOS = \left(\sum_i C\ (y_i) - C\ (y)\right) / C\ (y). \tag{3.9}$$

Hence, product-specific economies of scale are the average incremental costs of producing the ith output divided by the marginal cost of producing the ith output. If $S_i(y) > 1$, then product-specific economies of scale exist in the production of the ith output. If $S_i(y) < 1$, there are diseconomies of scale.Multiproduct economies of scale, $S_m(y)$, measure the change in costs for proportional changes in all outputs and inputs. Following Baumol, Panzar, and Willig (1988) and Kim (1987), a measure of scale economies for a multiproduct firm is defined as

$$S_m(y) = C(y)/\sum_i y_i C_i(y) = 1/\sum_i e_{cyi} \qquad 3.10$$

Where $C_i(y) = \partial C(y)/\partial y_i$ is the marginal cost with respect to the ith output, and $e_{cyi} = \partial \ln C(y)/\partial \ln y_i$, the cost elasticity of the ith output. If $S_m(y) > 1$, there exists economies of scale, meaning that a proportional increase in all outputs leads to a less than proportional increase in total cost. If $S_m(y) < 1$, then there exists diseconomies of scale.

In view of this, the functional specification applied to carry out the estimation is represented by the following generalized translog function:

$$\ln c = \alpha_0 + \sum_i^m \alpha_i \ln w_i + \sum_i^m \sum_{j\geq i}^m \alpha_{ij} \ln w_j + \sum_i^n \beta_i \ln y_i + \delta_{ij},$$

$$\sum_i^n \sum_{j\geq i}^n \beta_{ij} \ln y_i \ln y_i + \sum_i^m \sum_j^n \delta_{ij} \ln w_i \ln y_j + \sum_i^n \sum_j^n \beta_{ij} \ln y_i +$$

$$\theta_1 T + \theta_2 T^2 + \sum_i^m \theta_{1i} T \ln w_i + \sum_i^n \theta_{1i} T \ln y_i \qquad 3.11$$

Where: C = Total logistics cost, w_i = VRS i, P_i = Quantity of Goods distributed in a year i, T = Time, α_0, α_I, β_i, β_{ij}, θ_1, $\theta_{\backslash 2}$, θ_{1i}, θ_{1i}, δ_{ij}, are parameter to be estimated.

The Total Cost Model

The total cost concept is a key to effectively reduce the total cost of logistics activities rather than focusing on minimizing each activity in isolation. (Lambert et al 1998) According to Aronsson et al (2003) the total cost concept is important seeing logistics decisions will affect different areas of the organization. Attempts to reduce individual costs in one area may be offset by increased costs in other areas; a trade-off situation illustrated in figure 3.1.

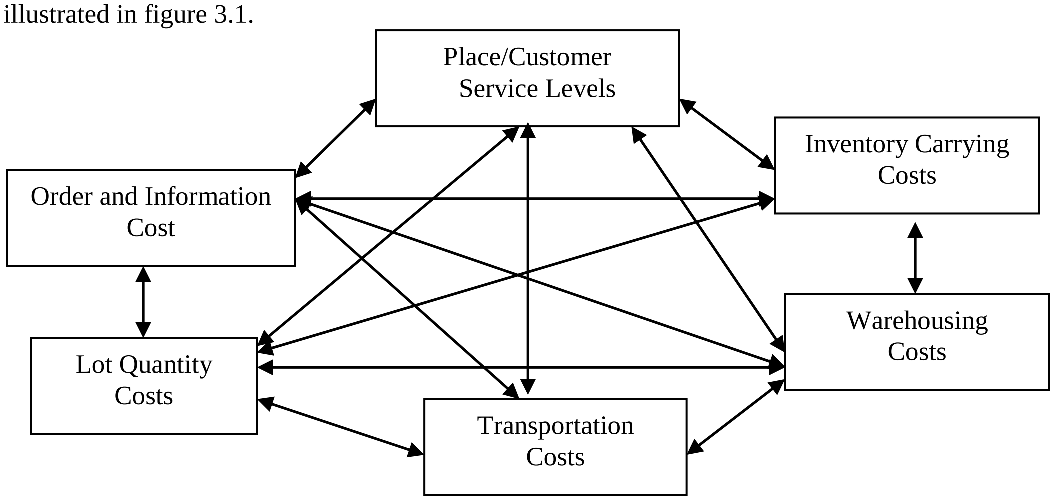

Figure 3.1: The Total Cost Model
Source: Adapted from Lambert et al, 2001

The Total Cost Model by Lambert et al (2001) presents six major logistics cost categories that are driven by a number of key logistics activities required to facilitate the flow of a product from the point of origin to the point of consumption (Fig.3.1) Both Lambert, et al (1998) and Aronsson et al (2003) states that what is included in total cost model varies depending on the outline of the logistics organization. In some situations components need to be removed from the model whereas other situations imply that more components are added to it. Apart from providing understanding to how different areas could be affected by changes within the organization, the Total Cost Model also provides a structure that helps identify activities that support the logistics process.(Somuyiwa, 2010a, 2010b, 2010c)

Analysis and Discussion

Table 4.1: Variables label and Definitions

Variables	**Descriptions**
VOD	Volume of goods distributed
TRc	Transportation cost
IFc	Information cost
MTc	Maintenance cost
SRc	Service cost
LBc	Labour cost
DGC	Distance over which the goods are carried
NDS	Number of Deliveries
WGD	Weight of Goods
ITc	IT Investment cost

Source: Field survey, (2012)

Table4.2: Zero-order Correlation Coefficients between the Dependent and Independent Variables of vehicle routine and scheduling Components

	VOD	TRc	IFc	MTc	SRc	LBc	DGC	NDS	WGD	ITc
VOD	-	0.763**	0.678**	0.665**	0.671*	0.712**	0.612*	0.523*	0.682*	-0.633*
TRc		-	0.611	0.735	0.521*	0.688	0.622	0.521	0.534**	0.644**
IFc			-	0.596*	0.572	-0.669*	- 0.528*	0.564**	-0.453	-0.456*
MTc				-	0.511	0.403	0.556*	0.412	0.321	-0.515*
SRc					-	-0.456	0.558	0.591*	0.336**	-0.542
LBc						-	0.566*	0.403	0.456	-0.675*
DGC							-	0.623**	0.612*	-0.531*
NDS								-	0.456**	- 0.661**
WGD									-	-0.634*
ITc										-

** Significant @ 0.05 level of significance * Significant @0.01 level of significance

Source: Fieldsurvey (2012)

Precisely, correlation analysis is basically on the relationship between and among variables in the data sets. The relationship in turn is usually in terms of establishing two things, which are the extent and direction. While the former concerns about existence of the relationship or otherwise, the latter emphasises on either positivism or negativism of the relationship.One general observation in Table 3.2 is that, there is moderately high positive and inverse inter-correlation among the dependent and independent variables. This perhaps makes the data sets not to violate the assumption of Multi-collinearity in the multiple regression model; because of correlation value of less than ± 0.8 as a rule of thumb as suggested by Hauser (1974) and Lewis-Beck (1980).

Perhaps of importance in this table is the fact that volume of goods distributed is not only positively correlated with all the independent variables, but also significant at 0.05 and 0.01 level of significances. This confirms the reliability, adequacy are accuracy of the data sets. However, IT investment is negatively correlated to virtually all the variables. The implication is that there is low IT investment as regards to the volume of goods distributed, consequently having negative effects on their respective operations. In a related manner, information cost is negatively correlated with labour cost. This implies that the more investment in information, the less the labour involved. Indeed, this is in line with economies of scale that will be discussed in the latter part of the paper. It is worthwhile to stress that the relative significance of all these variables relatively to one another emphasizes the importance of VOD as a surrogate for VRS.
In the same vein, the multiple regression results showed that all the variables could only account for 62.3% of their relative importance in VRS as presented in table 4.3. It is important to note that this value is significant at 0.05 level of significance.

Table 4.3: Multiple Regression Generation Model for Components of Vehicle Routine and Scheduling Cost Dependent VOD (Volume of Good)

Independent Variables	**b Coefficient**	**Standard Error of b**	**Beta weight**	**T-value**	**Sig**
TRc	56.432	14.231	.258	2.436*	0.015
IFc	43.123	11.433	.332	2.106**	0.000
MTc	45.421	12.331	.246	2.658*	0.003
SRc	35.522	9.521	.532	3.552*	0.000
LBc	48.391	13.534	.132	3.351**	0.002
DGC	23.532	7.344	.521	2.678*	0.001
NDS	15.321	3.897	.244	3.126**	0.021
WGD	-16.553	3.217	-.329	-3.633**	0.002
ITc	-7.342	1.785	-.552	-2.567*	0.005
CONSTANT	73.145	21.224		3.816**	0.000

VOD=73.145+56.432(TRc)+43.123(IFc)+45.421(MTc)+35.522(SRc)+48.391(LBc)+23.532(DGC)+15.321 (NDs)-16.553(WGD)-7.342(ITc)+e
*Significant @0.01 level of significance
**Significant @ 0.05 level of significance
Multiple R=.789
R^2 =.6225 or 62.3%
Adjusted R^2 =0.5825
F-value =2.231**
Source: Author's computation (2012)

Table 4.4 Cost elasticities of input VRS Resources

	TRc	IFc	MTc	SRc	LBc	ITc
TRc	-0.8821	0.9861	1.9564	1.8567	0.9843	0.4325
IFc	0.5632	-2.8563	0.4321	0.3412	0.3210	0.7121
MTc	1.8456	0.4521	-0.9812	0.4328	0.2561	0.3466
SRc	1.7832	0.4332	0.4932	-0.6723	0.4121	0.4521
LBc	1.5676	0.3267	0.5721	0.3671	-0.8892	0.5411
ITc	0.5421	0.3184	0.3456	0.5623	0.3266	-0.4531

Source: Author's computation (2012)

In table 4.4. it is obvious and expected that own-cost input demand elasticities (main diagonal) were all negative, indicating that an increase in an input VRS resources leads to a decrease in the demand of any of the activity centre. Of the six inputs, the own cost elasticity of information was highly elastic, or cost responsive at -2.8563. This implies that for one percent increase in the information cost, quantity to be effectively distributed will decrease by 2.85%, or perhaps, if wages in information centre go up by 5%, employment falls by less than 14.25%. This could be so when one considers the fact that for effective VRS, adequate information must be of paramount compared to other activity centre like Maintenance Transport and Service, where little educational status is required in order to do some basic things in the operations of their facilities. It is in the light of this that would make information to be inelastic. Similarly, the least cost responsive of the six inputs was IT investment cost whose own-cost elasticity was calculated to be -0.4531, indicating that an increase in IT investment cost will reduce the information cost by 7%. This is obvious due to the fact that comprehensive investment in IT will enhance information dissemination, which is the thrust of VRS. It goes to confirm that IT investment is an important area where cost could be saved among the resources in all the activity centres. This is further confirmed by the cross-cost elasticities (off-diagonal cells in table 4.4.) which were all positive, indicating substitution possibilities between input resources of information and IT investment cost.The paper further examined the possibility of economies of scale in the course of distribution based on grouping of these companies (Somuyiwa, 2010). This is presented in table 4.5

Table 4.5 Cost elasticities of grouped companies

Agric/Agro allied Group	0.2456
Breweries/Soft drinks Group	0.5631
Food Group	0.1345
Others	0.0956

Source: Author computation (2012)

Group distribution economies of scale, calculated as the reciprocal of the sum of cost elasticities ($1/\sum_i e_{cyi}$), measures the change in cost for proportional changes in all outputs. The calculated value (2.1785) indicates that increasing economies of scale are present in companies, if they are grouped, meaning that companies enjoy cost advantages from distribution in fixed proportions, assuming that input cost and resource abundance are constant. The presence of increasing economies of scale is not surprising given that, in the presence of output regulations, companies should be trying to minimize their distribution costs by operating in the area of increasing returns to scale through the use of effective and efficient VRS equipment.

Conclusion

Vehicle routing and scheduling has an effect on logistics and precisely physical distribution, it is therefore an important aspect of transportation decisions in outbound logistics. Again, managers should keep the following issues in mind when making decisions in distribution activities:

Distribution companies should place greater emphasis on the need for optimal solutions in Vehicle Routing and Scheduling in order to minimize total distribution cost, through the use of technology to improve transportation performance. Logistics Manager must use the information technology to help decrease costs and improve responsiveness in their transportation networks. These technologies help managers to do transportation planning and model selection, and build delivery routes and schedules. Available technology allows carriers to identify the precise location of each vehicle as well as the shipments the vehicle carries. Satellite – based communication system allow carriers to communicate with each vehicle in their fleet. These technologies can help a carrier become more responsive and also help lower costs by better matching shipments from customers with vehicles that are best suited to carry them. These technologies can also help a firm react better to unforeseen changes caused by the weather or other unpredictable factors.

On the final analysis, the paper has created awareness of the importance of keeping track of VRS costs are generated in transportation within companies, thus, it can be said that it is cost that determine how well a distribution business is run, while unnecessary mistakes can be avoided within companies. Although, it is not uncommon for business to start projects that potentially can yield more business and in the last minute become aware of the fact that to implement, it would demand so many resources that the implications would be severe. The question is not how much money can be made; it is how much insight a company has into its cost base, it is then that prices can be set, profit can be maximized and customers' requirements can be met. If everything is seen as a possible resource a potential output can be achieved. In the end costs are not everything that should be focused upon when performing economic modeling, but cost drivers are also important.

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