

Assessment of Economies of Scale in Multiproduct Manufacturing Companies of a Developing Economy

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Abstract

Attempts to overcome the problem of complex trade-offs among components of logistics cost have resulted in the creation of supply chain management and consequently ushered in detailed analysis such as holistic approach that hitherto impossible. It is in the light of this that the paper examines the potentials of economies of scale in downstream logistics of manufacturing companies of a developing economy, with a view to harnessing various cost components of this outbound logistics, such that customer service could be enhanced and competitive advantage could be achieved.

The paper adopted a case study approach, and collected primary data through questionnaires administered on twenty manufacturing companies based on multistage sampling techniques. The 110-item questionnaire elicits secondary data on components of outbound logistics for the period of 2002-2006. The data were analysed using a software application that was packaged and designed for the study and incorporated Generalised Translog cost function that places no priori restriction on the elasticities of substitution between the various restrictions such as homoscedasticity, homogeneity and unitary elasticities of substitutions, as well as its flexibility for allowing testing for specific characteristics of technology, input demand elasticities, economies of scale and output cost elasticities.

The findings revealed economies of scale and scope among input of outbound logistics resources indicating that logistics costs are characterized by joint distribution process, consequently concluded that resources management should be based on multiproduct distribution theory, and that explicit recognition of the economic interactions among resources should be incorporated in any regulatory process, through various categories of logistics service providers that must be encouraged in the country. The paper then recommended that group distribution by logistics service providers, as well as outsourcing be encouraged. This is in order to promote economies of scale which reduces cost, enhances fleet management, as well as customers' satisfaction.

Keywords: Assessment, Economies, Scale, Multiproduct, Manufacturing, Economy

1. Introduction

The cost analysis of 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 (Somuyiwa, 2010). 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.

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 homoeasticity, 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) and Pozdena and Merewitz (1978) were the pioneers to use translog for transport cost and /or demand modeling, and more recent Somuyiwa,(2010).

The functional form selected to represent a cost function needs to meet certain regularity conditions to ensure that it is a true cost function, that is, a function consistent with the idea of achieving a certain production volume at the minimum expenses, on the basis of certain given factor prices (Christensen, Jorgenson and Lau, 1973). It is widely known that the appropriate functional form representing a cost function must be non-negative, linearly homogenous, concave and non-decreasing in factor prices. Furthermore, a cost function must be non-decreasing in outputs when assuming free disposability (Caves, Christensen and Tretheway, 1980).

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 priori (De Borger, 1984).

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, and others, through relatively simple texts of an appropriate group of estimated parameters. Generalized cost functions like the translog have provided a convenient framework for analyzing logistics activities in manufacturing companies. An important characteristic of the translog cost function is its flexibility, allowing testing for specific characteristics of technology. Binswanger (1974) and Ray (1982) used translog cost functions to derive estimates of elasticities of demand and elasticities of substitution for the manufacturing sector in U.S.

In order to estimate the technical change and the technology of port operations – taken as the services provided by infrastructure and cargo handling, Kim and Sachis (1986) specify a long-run total cost function. Similarly, Chen (2000; 2002) examined intermodal transport competition in Taiwan and cost structure of the Taiwan railway industries, as well as established its labour-intensive nature. The translog cost function employed revealed that substantial economies of density were present in the operations of the railway. This implied that unit cost increased less than proportionately with output given fixed capacity. The author, however, concluded that fuel and intermediate factors are complementary, while the other input factors are substitutes. In the light of the above, the objective of the paper is set to analyse economies of scale in multiproduct manufacturing companies with a view to examining possibility of input demand elasticity, output cost elasticities and own-price elasticity and other advantages that can derived, using translog cost function.

2. Methodology/Study Area

2.1 Study Area

South-Western part of Nigeria lies between latitude 6°N and $8\frac{1}{2}^{\circ}\text{N}$ of the equator and longitude 3°E and 5°E 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 Geo-political 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

In a related development, major population concentrations are found in the state capitals and other important towns in the region. 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 tangentially determine the rate of the distribution of these products (Somuyiwa, 2010).

The paper adopted a case study approach, utilising detailed and sectionalized questionnaires as data collection instrument from twenty manufacturing companies located in southwest of Nigeria based on multistage techniques. The major criterion used to choose manufacturing companies is that these companies must be involved in multi-product nature of manufacturing activities that enhances efficient distribution. Moreover, questionnaire elicited primary data on components of outbound logistics that were related to cost for the period of 2002-2006 and were analysed using a software application that was packaged and designed for the study. The analysis was conducted by using a software application that incorporated Cobb-Douglas production and

Generalised Translog cost function was developed and used. The software was packaged and tailor-made to share this purpose alone, test various hypotheses stated and complement the results from the SPSS package.

3. Literature and Conceptual Underpinning

3.1 Multioutput Cost function

The discourse of the multiproduct cost function is similar to that for single-output-case. Consider the cost minimization problem for an m-output, n-inputs technology:

$$\text{Min } C = \sum_i r_i x_i \text{ subject to } F(y_1, \dots, y_m, x_1, \dots, x_n) = 0. \quad 3.1$$

From the Lagrangian

$$L = \sum_i r_i x_i + \lambda F(y_1, \dots, y_m, x_1, \dots, x_n), \quad 3.2$$

The first order conditions yield

$$\frac{\partial L}{\partial x_i} = r_i + \lambda F_i = 0, \text{ for } i = 1, 2, \dots, n \quad 3.3$$

$$\frac{\partial L}{\partial \lambda} = F(y_1, \dots, y_m, x_1, \dots, x_n) = 0 \quad 3.4$$

Solving the (n + 1) equations generates the conditional factor demand function

$x_i^* = x_i^*(r_1, \dots, r_n, y_1, \dots, y_m)$, for $i = 1, \dots, n$. The multioutput cost function C^* is then determined by substituting the conditional factor demand equations into the primal cost function C , resulting in $C^* = C^*(r_1, \dots, r_n, y_1, \dots, y_m)$. C^* gives the minimum cost for producing specified outputs.

Technical interdependence and economic interdependence are two concepts associated with multiproduct cost function. Beattie and Taylor (1985) show that technical interdependence can be expressed as

$$\frac{\partial^2 C^*}{\partial y_i \partial y_j} = \frac{\partial MC_i}{\partial y_j} \quad 3.5$$

Thus, the products y_i and y_j are said to be technically competing, independent, or complementary depending

upon whether the sign of $\frac{\partial^2 C^*}{\partial y_i \partial y_j}$ is positive, zero, or negative. Economic interdependence, as shown by

Beattie and Taylor (1985) refers to the interrelationships between two factors, two products, or a product and a factor, and involves determining what happens to quantity demanded or quantity supplied as a certain cost

changes. Specifically, factors x_1 and x_2 are economically complementary if $\frac{\partial x_1}{\partial r_2} < 0$, economically competing

if $\frac{\partial x_1}{\partial r_2} > 0$, and economically independent if $\frac{\partial x_1}{\partial r_2} = 0$. for product interdependence, with products y_j and y_k ,

and p_k representing the output cost of y_k , $\frac{\partial y_j}{\partial p_k} < 0 \Rightarrow y_j$ and y_k are economically competing, $\frac{\partial y_j}{\partial p_k} < 0 \Rightarrow y_j$ and

y_k are economically complementary, and y_j and y_k are economically independent.

Regarding factor-product or product-factor cross-cost effect, for normal products and normal factors, $\frac{\partial y_{j1}}{\partial r_1} < 0$

and $\frac{\partial x_1}{\partial p_{j1}} > 0$. That is, an increase in a factor cost would result in a decrease in the quantity supplied of any

product utilizing that factor, and an increase in an activity cost would generate an increase in factor demand.

Non-jointness in inputs is another important concept pertaining to multioutput technology. It implies a separate production function for each output. According to Hall (1973) and Shumway, Pope and Nash (1984) the technology is nonjoint in inputs if the cost function can be written as

$$C = \sum_i y_i C_j(r, y_i) \quad 3.6$$

where C_i is the individual cost function for the i th output. Non-Jointness in inputs implies that $\frac{\partial^2 C}{\partial y_i \partial y_k} = 0$, or

marginal cost of producing the i th output does not depend on the level of the k th output, $k \neq i$. A necessary condition for non-jointness in inputs is $\partial y_i / \partial p_j = 0$. That is, a cost change in the j th output will not affect the supply of the i th nonjoint output.

3.2 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 and Akridge and Hertel 1986) is

$$\sum_i C(y_i) > C(y), \quad 3.7$$

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 (2.38), $C(y)$ provides a measure of the degree of economies of scope, where economies of scope exist if $EOS > 0$:

$$EOS = (\sum_i C(y_i) - C(y)) / C(y). \quad 3.8$$

Baumol *et al.* (1988) identify two cost sources from which economies of scope can arise. The first source is cost complementarity, which implies that the marginal cost of producing one output is lowered by an increase in production of the other output:

$$\frac{\partial^2 C(y)}{\partial y_i \partial y_j} < 0 \quad 3.9$$

The second source from which economies of scope arise is represented by subadditive fixed costs. The multiproduct cost function can be expressed as a sum of fixed costs (F) and variable costs (V), $C(y) = F + V(y)$. Fixed costs depend on which product sets are produced. Two product sets T_i and T_j share some fixed costs when fixed costs are subadditive:

$$F(T_i) + F(T_j) > F(T_i \cup T_j). \quad 3.10$$

In other words, a cost function is sub additive at output y if it is more expensive for two or more firms to produce y than it is for a single firm to produce y .

The cost function represents an efficient mechanism used to reveal the technical and economic interrelationships present in a company. Because input variables are used as independent variables, the cost function overcomes problems associated with unknown input quantities. This means that one needs to know just total cost and input costs to find optimal input quantities.

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

$$\begin{aligned} \ln c = & \alpha_0 + \sum_i^m \alpha_i \ln w_i + \sum_i^m \sum_{j \geq i}^m \alpha_{ij} \ln w_j + \sum_i^n \beta_i \ln y_i + \delta_{ij}, \\ & \sum_i^n \sum_{j \geq i}^n \beta_{ij} \ln y_i \ln y_j + \sum_i^m \sum_j^n \delta_{ij} \ln w_i \ln y_j + \sum_i^n \sum_j^n \beta_{ij} \ln y_i + \\ & \theta_1 T + \theta_2 T^2 + \sum_i^m \theta_{1i} T \ln w_i + \sum_i^n \theta_{1i} T \ln y_i \end{aligned} \quad 3.11$$

Where: C = Total logistics cost, w_i = Transport cost i , P_i = Quantity of Goods distributed in a year i , T = Time, α_0 , α_i , β_i , β_{ij} , θ_1 , θ_2 , θ_{1i} , θ_{1i} , δ_{ij} , are parameter to be estimated. This equation is estimated together with factor-derived demand equations of Shephard's lemma and a group of restrictions placed on the parameters commonly used in translog functions to ensure homogeneity of degree one in factor prices of the cost function. Estimation was performed following the iterative technique modified by Zellner.

4. Analysis and Discussion

4.1 Translog Empirical Model

As indicated in paper, the cost function was used to reveal technical and economic interrelationships present in Activity Centre of manufacturing companies. It is assumed that adoption of cost structure function will holistically reduce cost and enhance customer satisfaction.

Specifically, the flexible translog cost function permits estimation of the increase in costs from a proportionate increase in all outputs (economies of scale), as well as the cost savings firm realize by producing several outputs jointly rather than specializing in the production of one (economies of scope). Finally, the translog cost function is flexible because it is not restricted to be monotonically increasing or decreasing as, for example, the Cobb-Douglas and CES specifications are. Thus one is able to estimate more realistic relationships between multiple inputs and outputs (Murray and White, 1983).

Mathematically, the translog cost function can be written for this study as:

$$\ln C = \ln a_0 + \sum_{i=1}^3 a_i \ln P_i + \frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 b_{ij} \ln P_i \ln P_j + \sum_{k=1}^4 c_k \ln Q_k + \frac{1}{2} \sum_{k=1}^4 \sum_{l=1}^4 d_{kl} \ln Q_k \ln Q_l + \frac{1}{2} \sum_{i=1}^3 \sum_{k=1}^4 e_{ik} \ln P_i \ln Q_k + \varepsilon \quad 4.1$$

Where C is Activity cost of each activity centre, Q_k ($k = 1, 2, 3, 4$) stands for the sub grouping of these companies that is, Agriculture/agro allied, Breweries/Soft drinks, foods and other group; P_i (1, 2, 3) represents the cost of resources, that is, Time, labour, equipment, maintenance, and service and a_0 , a_i , b_{ij} , c_k , d_{kl} , and e_{ik} are parameters to be estimated. For this function to be homogeneous of degree one in input costs, the following conditions must hold: $\sum_i a_i = 1$, $\sum_j b_{ij} = 0$, and $\sum_k e_{ik} = 0$. These theoretical conditions were first tested

and then imposed on the estimation (as discussed earlier), all within the context of an Ordinary Least Square (OLS) estimator as implemented in Visual Basic Programming that was used for the analysis.

Multiproduct economies of scale, $S_M(y)$, measure the change in costs for proportional changes in all outputs and inputs. Following Kim (1987) a measure of scale economies for multiproduct firm is defined as

$$S_M(y) = C(y) / \sum_i y_i C_i(y) = 1 / \sum_i e_{cyi}, \quad 4.2$$

Where $C_i(y) \partial y_i$ is the marginal cost with respect to the i th output, and $e_{cyi} = \partial \ln C(y) / \partial \ln y_i$, the cost elasticity of the i th 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. A measure of multiproduct economies of scale, as found in Akridge and Hertel (1986), is calculated using $S_M(y) = \sum_i \partial \ln C(y) / \partial \ln y_i$. Multiproduct economies of scale exist if $S_M(y) > 0$.

For the analysis, the models variables label, and definitions are presented in Table 1 while the results are reported in Table 2.

The test of overall model significance that all model coefficients were 12.332 (model F-value = 73.251), indicating that the estimated model was significant in describing cost relationships in the logistics resources of manufacturing companies. This can further ascertain that there is a relationship between total activity cost and outbound logistics resources. In addition, a large proportion of the variation in the dependent variable (log(total cost)) was explained by the estimated model (R-squared = 0.6867 or 68.7%) of the 52 estimated model parameters, 32 were statistically significant at the 0.05 percent level of significant, with 14 additional coefficients significant at 0.01 level of significance. Specifically, highly significant variables were resources cost (Equipment, labour, maintenance and service), other group; interactions between input resources, and most of the interaction terms associated with Breweries/soft drink group and food group.

The negative sign associated with the output interaction coefficients suggests that a cost reduction might be possible if resources are harnessed. In the translog function, however, the many interaction terms make the individual estimated coefficients difficult to interpret directly. As an alternative, these coefficients can be used to calculate own – and cross-cost elasticities of input demand, cost elasticities and economies of scope and scale.

4.2 MultiResources Cost Structure

The estimated parameters of the translog cost function can be used to determine how costs might increase given a proportional increase in outputs (economies of scale), as well as the cost savings companies might realize by distributing several products jointly rather than specializing in the distribution of one product (economies of scope). In the translog model, the necessary parameter condition for there to be economies of scope is if $c_{kl} < 0$. This nonlinear restriction cannot be directly tested in this linear model. Economies of scope can, however, be calculated from the estimated model parameters as depicts in table 3.

As can be seen from Table 3, substantial economies of scope were found between Food and Others Industrial groups, as well as Breweries/Soft drinks groups and Food groups, may enjoy cost complementarities or jointness in their distribution, implying that an increase in the distribution of one leads to a decline in the marginal cost of distribution of the other. Evidence of economies of scope was also found between Agric and Agro allied groups and Others group, similarly between Food Group and Agric and Agro allied Groups. Surprisingly, there were no economies of scope, or cost complementarity, between Agric/Agro allied and Breweries/Soft drinks groups or between other group and Breweries/Soft drinks groups. The import of all these is that companies can complement each other in the area of outbound logistics activities through logistics service providers that will make these companies to concentrate on production while the service provider will handles distribution that will all enhance promptness and cost saving which are basic ingredients of logistics. Although, this has be in practiced at micro level among some companies, such as Trade Channels Limited that is handling Warehousing, Inventory and Transportation management for Shell lubes.

Similarly, distribution specific economies of scale were measured by calculating the cost elasticity with respect to an output:

$$e_{cyi} = \partial \ln C(y) / \partial \ln y_i. \quad 4.3$$

Taking the derivative of the estimated translog cost function with respect to the log of each output, cost elasticities were calculated by holding constant all variables at mean levels (Table 4). In all cases that were measured, an inelastic response of cost to changes in logistics Resources and Industrial grouping, indicating

product specific economies of scale for each company. In particular, cost elasticities for Breweries/Soft drinks and Food groups were very small, meaning that these groups of companies can lower unit costs by expanding the scale of distribution for these companies. For example, a 1 percent increase in Breweries/Soft drinks (Food group) distribution results in 0.031 (0.094) percent increase in total cost. Even though economies of scale are present in the group distribution, however, the development of companies specialized in distributing its own is unlikely because of the technical advantages and other environmental variables that can constraint effective and efficient grouping. Again, logistics service providers are not well pronounced in the country. Hence, the implication of this are what have been revealed above.

Group distribution economies of scale, calculated as the reciprocal of the sum of cost elasticities ($1/\sum_i e_{cvi}$),

measures the change in cost for proportional changes in all outputs. The calculated value (2.055) 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.

5. Policy implication and conclusion

The main thrust of this paper, as initially stipulated, was to analyse possibility of economies of scale in multi-product manufacturing companies within the framework of cost structure and interrelationships among logistics cost and resources of each activity centre by estimating a group distribution cost function. The existence of jointness-in-inputs suggests that, to some degree, all inputs are required to produce all outputs. Thus, from distribution management perspective, individual regulation of components will affect the distribution process of the other components.

Again, Translog cost function adopted, did not only assist in grouping these companies based on similar features, but equally found that variables are significant, and conform to Translog function. Moreover, the presence of negative variables among the results indicated that output interaction coefficient of Translog exhibits that a cost reduction is possible, *ceteris paribus*, if resources are harnessed.

Similarly, economies of scope were found between pairs of certain group of companies, such that complementarities or jointness in their distribution by logistics service provider will be beneficial. Above all, increasing economies of scale are present in Breweries/Soft Drinks group. This indicated that the companies can enjoy cost advantages from distribution in fixed proportions.

In a related development, nonjointness-in-inputs and input-output separability and deriving input logistics resources of elasticities, the group distribution cost structure (economies of scope and scale) was also examined for technical and economic interrelationships. The results showed important economies of scope, especially between Food subgroup and most of the Other sub groups in the grouping categories of the companies. The strong cost incentives to distribute food subgroup, for instance, because of economies of scope and distribution specific economies of scale make food subgroup vulnerable to excessive distribution and consequently incur more cost. However, output regulation on food sub group may distort the economies of scope, leading to cost inefficiency in the distribution and generating spillover effects on jointly distribution groups.

The paper consequently recommended that government should support with adequate and enabling environment, for effective and efficient running of devices. The paper further suggests that Logistics Department should be established at companies with their responsibility clearly spelt out. The department of Logistics have the ultimate responsibility to give general directions on how the internal material and finished products will reach the customers in a seamlessly. The goal is to deliver the products in the right time at the lowest possible cost. The cost model can for example be used when deciding how the products should be distributed at lowest cost.

Moreover, there must be encouragement of group distribution by logistics service providers, in order to promote economies of scale and scope that will ultimately reduce costs and enhance customers' satisfaction. For the grouping of companies, jointness-in-inputs and non- separability between inputs and outputs suggests that resource management should be based on multiproduct distribution theory, and that explicit recognition of the

economic interactions among resources should be incorporated in any regulatory process, through various categories of logistics service providers that must be encouraged in the country.

Again in a situation like multiproduct technology, restrictions placed on overall logistic effort might be a better alternative to regulating individual inputs. However, the multidimensionality of logistics activities, often makes it difficult to manage, are simultaneously reduced.

Management strategies implemented in outbound logistics have generally not taken into account multi-grouping interactions and distribution effects. In a multi-grouping context, interactions between groups of companies need to be explicitly considered when deciding how to best manage distribution strategies and these interactions may be dependent on network, skill, expertise and economic base of logistics service providers. This is predicated on the fact that most of these products react to socio-economic and environmental variables of consumers, in which the service providers has to take into consideration

The technical and economic interrelationships empirically measured in this study indicate that logistics service providers management approaches should be employed in the companies grouping to account for the multigroupings interactions and the logistics potential overall impact on the national economy. A management system with secure access privileges could be an alternative to the insecure access privileges currently used in logistics activities. The key feature of this alternative system would be market-based approach that would, simultaneously decentralize management and encourage outbound logistics, orientation from self distribution and contracting of logistics activities.

In summary, the paper has made the above-mentioned contributions to the literature of the downstream logistics in particular and logistics activities in general in the area of modeling cost measurement problem through cost structure function analytical techniques and consequently creates a map of the outbound logistics functions, that will in turn provide a basis for decision-making regarding the utilization of the adequate production and distribution for those companies

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Table 1. Variables labels and Definitions

Variables	Description
TAc	Total Activity Cost
AAAg	Agric/Agro Allied Group
BSDg	Breweries/soft drink group
FDg	Food group
Others g	others group
Time	Time
Labour	Labor
Equip	Equipment
Matce	Maintenance
Service	Service.

Source: Author's fieldsurvey (2009)

Table 2. Estimated Coefficients and associated statistics of the unrestricted Translog cost function for Total Activity Cost of Outbound Logistics

Variable	Parameter Estimate	Standard Error	T.Value	Pr> t
TAc	1.14647	0.06191	3.11**	0.005
AAAg	-2.83061	0.38897	-2.14*	0.034
BSDg	1.31766	0.37827	4.84**	0.002
Fdg	1.91427	0.25387	0.06	0.955
Others g	2.03200	0.43978	3.17**	0.004
Time	17.71765	4.12651	3.07**	0.009
Labour	3.94854	0.92792	2.81**	0.001
Equip	6.72490	0.66402	2.24**	0.006
Matce	1.13689	0.00562	6.56**	0.000
Service	-2.10032	0.00311	-2.10*	0.001
(AAAg)^2	-3.00902	0.00235	-1.83	0.512
AAAg*BSDg	-1.12368	0.00479	-4.94**	0.000
AAAg*FDg	2.11001	0.00611	1.64	0.104
AAAg*others	-3.01185	0.00268	-4.32*	0.005
(BSDg)^2	-2.09955	0.00304	-0.18	0.858
BSDg*FDg	1.02287	0.00392	5.83**	0.000
BSDg*others	-3.01845	0.00260	-3.25*	0.001
(FDg)^2	2.91705	0.00515	3.31**	0.001
FDg*others	4.00239	1.55691	3.11*	0.000
(Others)^2	-5.04647	0.17059	-3.27*	0.000
(Time)^2	-6.40928	0.31022	-2.32*	0.008
Time*Labour	-4.19657	0.4942	-2.95*	0.004
Time*Equip	-5.11570	0.02210	-5.23**	0.000
Time*Mtce	3.16464	0.02461	2.63**	0.009
Time*Service	4.22792	0.06989	3.26**	0.001
(Labour)^2	-3.03653	0.01636	-2.23*	0.002
Labour*Equip	2.01217	0.00929	4.23*	0.008
Labour*Mtce	-1.16870	0.06884	-4.00*	0.003
Labour*Service	2.11078	0.01261	4.86**	0.003
(Equip)^2	1.10620	0.00862	1.26	0.981
Equip*Mtce	3.02761	0.04612	3.60**	0.005
Equip*Service	-2.10188	0.00959	-1.20	0.845
(Service)^2	3.06668	0.00489	-3.37**	0.004
AAAg*Time	4.02594	0.07446	3.35**	0.002
AAAg*Labour	1.90294	0.01253	4.23**	0.008
AAAg*Equipt	3.10422	0.01010	3.42**	0.006
AAAg*Service	-4.1904	0.01235	-2.84**	0.000
BSDg*Time	-5.62490	1.55301	2.42**	0.001
BSDg*Labour	-4.17193	0.15786	-3.13**	0.002

BSDg*Equip	4.03356	0.00272	4.8**	0.000
BSDg*Mtce	2.30614	0.21011	3.32**	0.000
BSDg*Service	3.33652	0.05776	3.16**	0.001
FDg*Time	1.11463	0.06335	4.45*	0.011
FDg*Labour	-3.00043	0.00221	-3.11**	0.000
FDg*Equip	-2.1458	0.00363	-3.75**	0.001
FDg*Mtce	1.62578	0.03386	7.64**	0.000
FDg*Service	3.03877	0.00306	6.15**	0.000
Others*Time	2.94954	0.25593	3.56**	0.000
Others*Labour	4.13227	0.00514	5.60**	0.000
Others*Equip	2.06873	0.02312	4.80**	0.004
Others*Mtce	-3.00316	0.00581	-2.45*	0.007
Others*Service	-2.14862	0.04310	-2.17*	0.001
Intercept	-17.6535	2.58096	-0.19	0.847
Model F-value = 73.251				
(Pr>F) = 12.332 R-Square = 0.6867				
** Significant @ 0.05 Level of significance				
* Significant @ 0.01 Level of significance				

Source: Output of Translog analysis of the Software developed based on fieldsurvey (2009)

Table 3. Economies of Scope: Parameter estimates

Industrial Groupings	$c_k c_l + d_{kl}$
Agric/Agro allied and Others Groups	-0.04977
Agric/Agro allied and Breweries/Soft drinks Groups	0.08846
Food Group and Others Groups	-0.28560
Food Group and Agric/ Agro allied Groups	-0.06059
Others Groups and Breweries/Soft drinks Group	0.16210
Breweries/Soft Drinks and Food Groups	-0.34617

Source: Output of Translog Analysis based on field survey (2009)

Table 4. Cost elasticities of grouped companies

Agric/Agro allied Group	0.23675
Breweries/Soft drink Group	0.03181
Food Group	0.09429
Others Group	0.12360

Source: Output of Translog Analysis based on field survey (2009)