Pakistan Journal of Social Sciences 5 (3): 226-234, 2008
ISSN: 1683-8831

The Spatial Pattern of Urban Goods Movement in Akure, Nigeria

Enosko Okoko
Department of Planning, Faculty of Planning and Land Economy,
University of Science and Technology, Kumasi, Ghana

Abstract: This study reports the pattern of urban goods movement in Akure, Nigeria. It examines a sample of the empirical pattern of urban goods movement in various landuse typologies in Akure town. The empirical pattern of interaction was subjected to gravity modeling and linear programming modeling to obtain predictions on the spatial pattern of urban goods movement, using the travel time as the impedance factor. The study identifies, through the modeling exercise, the urban landuse typologies that are major generators of urban goods transport and the landuses that are major attractors of urban goods trips in the city. Recommendations and policy issues are advanced based on the findings of the study.

Key words: Spatial pattern, urban goods, movement, landuse, Nigeria

INTRODUCTION

Urban transportation literature is replete with discourses and research reports on the pattern and nature of movement of commuters, private cars, mass transit and paratransit vehicles in the urban areas. On the other hand, there is a palpable dearth of research reports in the area of goods transportation in the cities. It is one word goods transportation is an important sub-set of the urban transportation system, ipsofacto, the factors that generate goods movement, their direction and pattern of movement and their relationship with the urban landuse pattern should be deciphered and characterized.

The dearth of data on goods movement is not only peculiar to the developing countries of the world, but rather, it runs throughout the gamut of all the continents. Available evidence reveals that even in the developed countries of the world, research on goods transportation has received only a scant attention. A case in point is in Canada, where it was reported that;

> "There is no reliable, comprehensive understanding of the cost of the goods movement system in urban areas. There is no systematic comprehension at the Metropolitan level of the complex interactions between land use, type of goods moved, nature of transfer operations, relationships between goods type, truck type and operating patterns (Transport Canada, 1979)".

Corporate and individual researches in the field of urban transportation have over the years ignored goods movement (ASCE, 1989; NCHRP, 1995; DOT, 1995; Anderson *et al*., 1996). Scientific and academic publications like conference proceedings and journals also carry very few or no article at all on urban goods movement. Giles (1997) for example, reports that a special issue of Scientific American which was focused on transportation, carried only (1) study on freight movement.

Some reasons have been adduced by transport planners to account for this apparent neglect or lack of academic interest in goods transportation research. One of the reasons is the fact that private cars, taxis and other public passenger transport are more numerous on the urban roads than goods transport and they therefore, contribute far more significantly to urban traffic congestion, pollution and traffic management challenges than goods transport. Consequently, the research efforts of transportation planners are directed towards cars and passenger public transport modes. In the UnitedStates of America, depending on the time of the day, trucks and other goods transport only make up 7-18% of traffic (DOT, 1995).

Byrue and Mulhall (1995) opined that the elements of freight movement and the actors involved are very complex and this makes it a difficult subject to research. Furthermore, there is the problem of accurate data collection or data availability on freight movements in the urban areas. It is easier to collect data on freight movement and truck movement at the inter-city level or regional level, but intra-city data are much harder to obtain.

The tenor of this study is to determine the empirical pattern of goods movement and then obtain predictions on the spatial distribution of freight trips

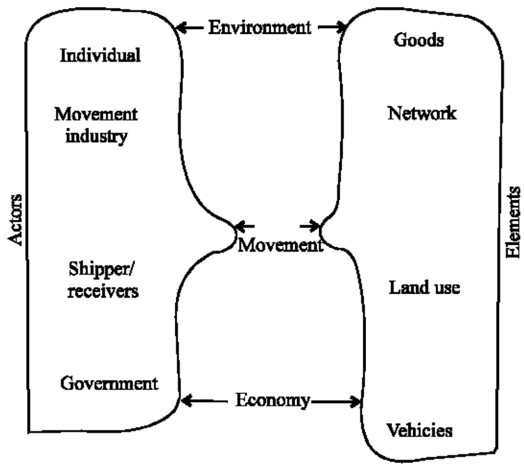

Fig. 1: A frameworrk for the study of urban goods movement (woudsma, 2001)

in Akure town using the entropy, gravity and linear programming models.

The Iconography of Urban Goods Movement (UGM): Woudsma (2001) defines Urban Goods Movement (UGM) as any movement of material goods (freights) rather than people. Goods movement is normally categorized into two classes, namely external and internal. External movements are those in which goods either enter, leave or pas through the city, while internal movements take place within the city boundaries. Both the external and internal goods movements involve various ranges of goods e.g. small parcels to heavy machinery, various modes e.g. pick-up vans to long trailers and various motivations for movement. It is therefore, incontestable that this represents a more complex milieu than that associated with the movement of people (Ortuzar and Willumsen, 1994).

Woudsma (2001) presented a model of urban goods movement (Fig. 1). The model or framework is made up of five component parts, namely ‘movement’, ‘actors, elements’, ‘Environment’ and ‘economy’. ‘Movement or transport of goods is the core and is affected by the inter relationships between the ‘actors’ and ‘elements’. The actors and the elements both constitute the physical aspects of the transport system.

The ‘actors’ in the framework represent groups and individuals whose decision-making directly or indirectly influences the character of goods movement. These decisions, according to Woudsma (2001) range from drivers’ decisions on vehicle safety and infrastructure investment. The ‘elements’ on the other hand represent the physical realm, including the nature of the goods themselves, the vehicle stock and the relationship between the transport system and landuse.

In the framework, the ‘actors’ and the ‘elements’ influence the environment and the economy. Conversely, they are also influenced by both the environment and the economy, which represent the overall sphere in which goods movement takes place. It has been reported that theories dealing with traffic flow, business decision-making a\and locational choice-find a place within this framework (Bourne, 1982; Giuliano, 1989).

UGM is a relatively novel area in urban transportation studies. Consequently, there is no single theoretical basis for exploring UGM. However, Ogden (1992) provided a summary of the elements of the major policy and planning objectives associated with UGM. His summary of the planning perspective on UGM is given in Table 1.

Another approach to the study of UGM is the one provided by Gainic and Laports (1997) which modeled freight movement from the operations research perspective. The success associated with their efforts prompted them to observe that Transportation Planning is undoubtedly one of the great success stories of operations research (Gainic and Laportz, 1997). A summary of the elements of an operations research perspective on modeling freight movement is given in Table 2.

UGM is usually analyzed using trip distribution models, e.g., entropy and gravity models with origin-destination data from the survey. This poses some problems for UGM research because these models were developed for the study of automobiles and commuters and not freight movement. Ruiter (1992) has suggested that truck movements should be converted to automobile movements via axle equivalents in order to operationalize the models. The techniques of adapting automobile based models to fit freight data have been advanced by Ortuzar and Williumsen (1994).

Studies have also shown that UGM is usually a small reflection of the urban traffic. In a study carried out in Canadian cities, it was shown that trucks as a percentage of traffic flow figures range from 3-20% and vary with local conditions and time of day considerations (Metropolitan Toronto, 1987; Vancouver City Engineering Department, 1990). The DOT (1995) stated that trucks only make-up 7-18% of urban traffic. The truck percentage in the urban traffic also depends on the classification of goods vehicle, for example, light trucks or pick-up trucks often make up a large portion of the urban traffic and if they are not included, the truck percentage of traffic plan is decreased.

The low percentage of trucks or goods vehicles on urban roads suggests that they are not a big part of the urban traffic congestion issue, though they constitute part of the traffic during peak hour hold-ups. The costs of

Table 1: Planning perspective on urban goods movement

Policy and planning objectives	Specific elements
Economic	Develop and improve the freight system towards improving the local, regional and national economy. Focus on ports and intermodal facilities
Efficiency	Minimization or reduction in transport operation costs related to en route travel, end-point activity and energy. Focus on congestion, role of freight and costs to freight.Road network deficiencies including road design and geometry, maintenance, signage, local area traffic management and arterial capacity. Endpoint costs associated with loading and unloading, parking, terminal activities, hours of operation and site access and aggress. Energy costs associated with vehicle speed and character and shipment type.
Road safety	Minimisation or property damage, injury and fatality – related accidents. Focus on policy related to traffic management, road design, vehicle design, driver training and land-use.
Environmental	Focus on mitigation of noise, air and vibration pollution.Perceived threat of large vehicles a\and intrusive activity in residential areas.
Infrastructure and management maintenance and	Explore government influence through regulations, pricing controls, taxation and investment. Road construction and its relationship with freight sector.
Urban structure	Focus on interaction between freight facilities and urban structure, including interaction between freight and urban structure, city size and its effects on freight costs and freight as a user of urban land.

Source: Ogden (1992)

Table 2: Operations research perspective on goods movement

Planning model	Specific elements
Strategic (long-term)	Design and upgrading of physical network (shortest spanning tree problem). Regional multimodal planning (spatial price equilibrium models). Location of main facilities (location – allocation) Resource acquisition Service and tariff policies
Tactical (medium time-frame)	Focus on the service network. Allocation and vehicle routing. Network simulation and optimization.
Operational (short-term)	Day-to-day decisions on resource use.

Source: Grainic and Laporte (1997)

congestion in relation to the overall cost for goods movement is always very high. Furthermore the costs of congestion for freight movement increase with increasing city size (Ingram, 1998). In view of the fact that most of the goods must meet the just-in-time manufacturing schedule in order not to interrupt the supply chain logistics in the consumer market, UGM must enjoy some form of flexibility, or even the establishment of separate truck lanes in the cities.

MATERIALS AND METHODS

This study was conducted in Akure, the capital city of Ondo state, Nigeria. The target population for the study was urban goods transportation. This involved all the non-passenger vehicles that transport goods from one part of the town to the other. They ranged from pick-ups to vans, trailers and trucks in the urban traffic, carrying various types of goods in the urban area.

Samples for this study were drawn based on the broad land use zonation of Akure. Urban goods movement trip origins and destinations were considered in terms of the broad land use categorization of the town i.e. public/semi-public uses, residential uses, commercial uses, industrial uses and institutional uses.

It must be pointed out that some of these zones are not contiguous, but the division of the town into these landuse typologies was done to ensure ease of collection and analysis of data. The sample was restricted to only those goods vehicles that circulate within the town only. Goods vehicles that had either their origins or destinations or both outside Akue were not covered in the sample.

Field agents ere instructed to sample only goods vehicles in the urban traffic and four survey points were selected in the town for the study. The survey points are: Isikan junction, NEPA junction, Ilesha garage and the main market (Oja-Oba). The survey was done on the same day and registration numbers of vehicles ere noted and later cross-checked to guard against double sampling of respondents. The choice of these survey points was informed by the fact that they were road intersections and driver are bound to slow, or obey the traffic wardens, thus making time for the field agents to collect their data.

Field assistants were told to collect information only on the types of vehicles, nature of goods carried, journey origin and destination. This was done to keeps the interview as brief as possible and also to ensure minimum delay to traffic. The survey was done within seven hours on the survey date. This was between 9.00 a.m. in the morning and 4.00 pm in the afternoon. The choice of this time frame was to avoid both the morning and evening rush hours.

The analytical framework that was employed in the analysis is the unconstrained gravity modeling, entropy-maximized gravity modeling and optimization modeling. The structural form of the unconstrained gravity modeling approach is given as follows:

$$X_{ij} = K.0_i.D_j\lambda_{ij-\alpha} \quad (1)$$

And the destination-constrained entropy model (or industrial zones location model) is given below:

$$X_{ij} = 0_i.\beta_j.D_j\lambda_{ij-\alpha} \quad (2)$$

Where,

$$\beta_j = \left[\sum_{i=1}^{n} 0_i\lambda_{ij-\alpha}\right]^{-1} \quad (3)$$

While the optimization modeling framework is stated as:

$$\text{Minimize } Z = \sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij}\lambda_{ij} \quad (4)$$

$$\text{Subject to: } \sum_{j=1}^{m} X_{ij} = 0_j \quad (5)$$

and

$$\sum_{i=1}^{n} X_{ij} = D_j \quad (6)$$

to ensure that:

$$X_{ij} \geq 0 \ (I = 1, 2, \ldots n, j = 1, 2, ..m) \quad (7)$$

Where,

$X_{ij} \geq 0$ = The non-negativity constraint.
n = Number of origins.
m = Number of destinations.
X_{ij} = Volume of goods trips interchange between i and j.
O_i = Volume of goods trips emanating from origin zones.
D_j = Volume of goods trips terminating in destination zones.
Λ_{ij} = Goods trip impedance between i and j (travel time).

The empirical pattern of distribution of goods transport trips in the town is shown in Table 3. The matrix of the average travel time from one zone to the other is given in Table 4. The average travel time from all homes to all work places in Akure has been computed, to be 18 min based on a survey by Okoko (2002). On the basis of this observation, the travel time from Alagbaka, Ilesha road and Oja-Oba to all the other residential areas in the town is assumed to be 18 min.

The choice of the traffic analysis zones was made to reflect the various landuse topologies in the town. Thus, Alagbaka zone represents the public/semi-public zone, Ilesha rod represents the industrial /institutional zones, Oja-Oba represents the commercial hob and then the various residential zones in the town were considered enbloc.

Table 3: Empirical pattern of goods trip distribution in Akure

$D_j/0_i$	Alagbaka	Ilesha road	Oja-Oba	Residential areas	$\Sigma 0_i$
Alagbaka	15	54	85	91	245
Ilesha road	54	52	132	48	286
Oja-Oba	67	88	06	149	310
Residential	18	31	175	43	267
ΣD_j	154	225	398	331	1108

Table 4: Matrix of mean travel time (in minutes $\overline{x}\lambda_{ij}$)

($\overline{x}\lambda_{ij}$)	5	15	10	18
	15	5	8	18
	10	8	5	18
	18	18	18	18

RESULTS AND DISCUSSION

Various types of vehicles are used in conveying goods from one point to the other in the urban setting in Akure. These vehicles include panel vans, pick-up vans, trucks, trailers and lorries. The materials carried include: Food stuff, textile materials, manufactured good like beverages, canned food, drinks, building materials, electronics, upholsteries, stationeries etc.

The empirical pattern of goods trip distribution shows that 22% of the trips (245) originated from Alagbaka area, 25.8% (286) originated from Ilesha road, about 28% (310) came from Oja-Oba and 24% emanated from the residential areas. This shows that the zone that emits or generates the highest volume of goods traffic in Akure is the Oja-Oba zone. This is understandable because Oja-Oba (King's palace market) is by far the largest commercial hub in Akure town. It therefore serves as a distribution point for urban goods. It is also noteworthy to note that most of the goods that emanate from the central market are consumer goods, because most of the trips (149) out of total of 310 trips ended up in residential areas, where they are consumed directly by urban dwellers. It is also interesting to note that a vast majority of urban goods from the residential areas end up in the market. This empirical pattern shows that the residential areas and the central market are the major pivots upon which urban goods movement rotate in Akure.

It is equally important to note that majority of the industrial goods and other goods produced in the Ilesha-road zone, which is more or less an industrial zone, also go to the market (132 trips out of a total of 286 trips). On the attraction or destination side, the central market attracts the highest number of goods trips in the study area. Out of a total of 1108 goods trips, that were attracted in the study area 448 (40.54%) terminated in the central market. The empirical pattern of goods movement portrays central market (Oja-Oba) as the largest generator and attractor of urban goods trips in Akure. The next major attractor of urban goods trip is the residential areas in the town. Out of a total of 1108 urban goods trips, 331 (about 30%) went to the residential areas for direct consumption by urban dwellers. The overall trip ends at both the origin and destination zones in the town are shown in Table 3.

The zonal distribution of trips in the study area is shown in Table 3. The table shows that most of the goods that left Alagbaka (91), an area of public/semi-public use and residential elements, went to residential areas in the town, while it received most of the goods trips (67) from Oja-Oba. Majority of the trips that left Ilesha road, an area of industrial, institutional and residential uses, went to Oja-Oba. Most of the urban goods trips that originated from Oja-Oba went to the residential zones in the town and Oja-Oba itself received the highest number of goods trips from the residential areas in Akure. A great deal of the trips from the residential areas went to Oja Oba and it also received its highest proportion of goods trips from Oja-Oba too (Table 3).

In order to predict the pattern of urban goods movement using travel time as the impedance factor and also in order to advice on the rational distribution of urban goods, the empirical pattern of distribution was subjected to a gravity modeling analysis. The exponent function that regulates the frictional effect of travel time on the pattern of urban goods movement was set at 2.0 and the constant of proportionality (k) in the equation (Eq, 8) was determined empirically using Eq. 9.

$$X_{ij} = K.\, 0_i.\, D_j. \qquad (8)$$

$$K = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} X_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{m} \frac{0_i.D_j}{\lambda_{ij^{-2}}}} \qquad (9)$$

The calibration of Eq. 9 using empirical data yielded the K value as:

$$K = 0.066910677$$

The calibration of Eq. 8 yielded the following urban goods trips distribution matrix:

The predicted pattern of urban goods trip distribution in Akure, based on the unconstrained gravity model and the travel time impedance factor is presented in Table 5. The highlight of the interaction matrix is that Oja-Oba and Ilesha road are predicted as the leading generators of urban goods trips in Akure town. The predicted trip volumes for these zones are higher than the empirical figures. For example, the number of goods trips generated in Oja-Oba increased from 310-498 and trips from Ilesha road increased from 286-339. This suggests the primacy of these zones as major commercial/industrial zones in the town.

The major urban goods attraction zones in the town as predicted by the model are Oja-oba and Ilesha road zones. The volume of urban goods trips attracted to Oja-Oba increased from 448-604 and the number attracted to Ilesha road also increased from 225-274. The predicted number of goods trips attracted to Alagbaka was synchronous with the empirical value 154. The residential areas turned out to be very poor generators and attractors of urban goods trips in Akure town. The noticeable concentration of goods trips along the major diagonal of the interaction matrix is explainable by the inherent tendency of the model to capitalize on lest frictional effect of the impedance factor.

The next stage of the analysis was to predict separately the best urban goods trip generating zones and also urban goods a trip attracting zones using synthetic models called the singly constrained entropy maximized models of trip distribution. To predict the urban goods trip generating zones, a mathematical constraint was placed on the destination zones so that trip ends at the destination zones did not vary. Only trip ends at the origin zones could vary and these variations constituted the predicted goods trips generating zones in the study area. The structural form of this synthetic model is given in Eq. 10.

$$X_{ij} = 0_i.\beta_j D_j \lambda_{ij^{-2}} = D_j.P_{ij} \qquad (10)$$

Where

$$p_{ij} = \beta_j 0_i \lambda_{ij^{-2}} = \frac{0_i \lambda_{ij^{-2}}}{\sum_{i=1}^{n} 0_i.\lambda_{ij^{-2}}} \qquad (11)$$

and

$$\beta_j = \left[\sum_{i=1}^{n} 0_i \lambda_{ij^{-2}}\right]^{-1} \qquad (12)$$

to ensure that:

$$\beta_j = \left[0_i \lambda_{ij^{-2}}\right] x\, 0_i.\lambda_{ij^2} = 1.0 \qquad (13)$$

Table 5: Unconstrained gravity model pattern of urban goods interaction matrix

$D_j/0_i$	Alagbaka	Ilesha road	Oja-Oba	Residential areas	$\Sigma 0_i$
Alagbaka	101	16	73	17	207
Ilesha road	13	172	134	20	339
Oja-Oba	32	73	372	21	498
Residential	8	13	25	18	64
ΣD_j	154	274	604	76	1108

Table 6: The destination –constrained pattern of urban goods movement

$D_j/0_i$	Alagbaka	Ilesha road	Oja-Oba	Residential areas	$\Sigma 0_i$
Alagbaka	101	14	49	73	237
Ilesha road	13	141	88	85	327
Oja-Oba	32	60	245	93	430
Residential	8	10	16	80	114
ΣD_j	154	225	398	331	1108

so that:

$$\sum_{i=1}^{n} X_{ij} = D_j \tag{14}$$

and

$$\sum_{i=1}^{n} X_{ij} \neq 0_i \tag{15}$$

The calibration of Eq. 10, using the destination constraint (β_j), the empirical interaction matrix (Table 3) and the impedance matrix (Table 4), yielded the following destination constrained goods trip distribution matrix (Table 6).

The calibration of the destination-constrained model (Eq. 10) yielded the spatial interaction pattern in Table 6. The constraint (Eq. 12) ensured that the predicted trip ends at the destination zones were the same as the empirical trip ends thus satisfying Eq. 14. The trip ends at the origin zones did not coincide with the empirical trip ends and consequently, Eq. 15 was satisfied. The new values obtained for trip ends at the origin zones now constitute the predictions made by the model in Eq. 10.

It is interesting to observe the similarity in the predictions for the D_1 column (Alagbaka zone). All the trips that terminated in the Alagbaka zone from Alagbaka itself, Ilesha road, Oja-Oba and the residential areas are exactly the same as the one predicted by the unconstrained gravity model. Like the unconstrained gravity model, the destination constrained model also predicted Oja-Oba as the major source region for urban goods in Akure. This should be understood from the perspective that only urban goods movement that originated and terminated within the town were considered. Most goods that enter the town from outside are taken straight to the main market (Oja-Oba) and from there, they are distributed to various parts of the town.

The second major origin zone predicted by the model is Alagbaka zone. In the empirical pattern of distribution, Alagbaka came last, but because of distance minimization consideration in urban goods trip distribution modeling, it now assume a second position. It is also important to notice a concentration of the trips along the major diagonal of the interaction matrix. This is so because of the reliance of the model on travel time minimization. For this reason, the model predicts that 245 urban goods trips out of the 430 trips that originated from the market should circulate in the market. The same predictions were made mutatis mutandis for all the other zones (Table 6) on the major diagonal of the interaction matrix. The highlight of the model is the prediction that urban goods in Akure emanate principally from: The main market (Oja-Oba), the main institutional, public/semi-public zone in the town (Alagbaka) and the industrial zone in the town (Ilesha road).

The next level of analysis was the adoption of the origin-constrained entropy maximized model to predict variations of trip ends at the destination zones. A mathematical constraint ($\forall_i$), was introduced into the origin zones to ensure that the predicted trip volumes at origin zones were the same s the observed trip ends. The origin-constrained model is used here to predict areas or zones of the town that received the highest volume of urban good trip. The model is stated as:

$$X_{ij} = \forall_i 0_i D_j . \lambda_{ij^{-2}} \tag{16}$$

Where,

$$\forall_i = \left[\sum_{i=1}^{n} D_j \lambda_{ij^{-2}} \right]^{-1} \tag{17}$$

to ensure that:

$$\sum_{j=1}^{m} X_{ij} = 0_j \tag{18}$$

and

$$\sum_{i=1}^{n} X_{ij} \neq D_j \tag{19}$$

The model (Eq. 16) yielded the urban goods interaction pattern shown in Table 7.

The trip ends at the origin zones ($\Sigma 0_i$) are the same as the empirical trip ends in Table 3, thus satisfying Eq. 18. The trip ends at the Destination zones (ΣD_j) are not correctly predicted thus satisfying (Eq. 19), so the discrepancies constitute the predictions. The model predicts that a large proportion of urban goods movement (505 0r 45.57%) will be attracted to the market (Oja-Oba). Another major attractor of urban goods as trips is Ilesha road, followed by Alagbaka zone. Again, the residential zones were the poorest attractor of urban goods movement in Akure, according to the origin-constrained gravity model.

Table 7: Origin-constrained urban goods interaction matrix

$D_j/0_i$	Ilesha Alagbaka	Oja-road	Oba	Residential areas	$\Sigma 0_i$
Alagbaka	124	20	80	21	245
Ilesha road	12	152	105	17	286
Oja-Oba	22	50	224	14	310
Residential	37	54	96	80	267
Σd_j	195	276	505	132	1108

Table 8: 'Minimized' Pattern of urban goods movement in Akure, Nigria

$D_j/0_i$	Ilesha Alagbaka	Oja-road	Oba	Residential areas	$\Sigma 0_i$
Alagbaka	$154^{(5)}$		$91^{(10)}$		245
Ilesha road		$225^{(5)}$	$61^{(8)}$		286
Oja-Oba			$246^{(5)}$	$64^{(18)}$	310
Residential				$267^{(18)}$	267
Σd_j	154	225	398	331	1108

The linear programming approach to optimization modeling was also applied to the analysis of the empirical distribution of urban goods movement in Akure. The idea was to find the least-time pattern of movements that would ensure that nothing was left unmoved at the origin zones while capacity constraints at the destination zones were also not violated. Thus the utility of this modeling approach is to minimize the travel time associated with urban goods movement in Akure. The model is normally stated as:

$$\text{Minimize:} \sum_{i=1}^{n} \sum_{j=1}^{m} X_{ij}.\lambda_{ij} \quad (20)$$

$$\text{Subjected to:} \sum_{j=1}^{m} X_{ij} = 0_i \quad (21)$$

$$\sum_{i=1}^{n} X_{ij} = D_j \quad (22)$$

The Lindo programme for this classical urban goods transportation problem is as given below:

$$\begin{aligned}
\text{Minimize}\quad & Z = 5X_{11} + 15X_{12} + 10X_{13} + 18X_{14} \\
& +15X_{21} + 5X_{22} + 8X_{23} + 18X_{24} \\
& + 10X_{31} + 9X_{32} + 5X_{33} + 18X_{34} \\
& + 18X_{41} + 18X_{42} + 18X_{43} + 18X_{44} \\
\text{Subject top:}\quad & X_{11} + X_{12} + X_{13} + X_{14} = 245 \\
& +X_{21} + X_{22} + X_{23} + X_{24} = 286 \\
& +X_{31} + X_{32} + X_{33} + X_{34} = 310 \\
& + X_{41} + X_{42} + X_{43} + X_{44} = 267 \\
\text{and}\quad & X_{11} + X_{21} + X_{31} + X_{41} = 154 \\
& X_{12} + X_{22} + X_{32} + X_{42} = 225 \\
& X_{13} + X_{23} + X_{33} + X_{43} = 398 \\
& X_{14} + X_{24} + X_{34} + X_{44} = 331
\end{aligned}$$

The solution to this problem was based on the matrix minimum method and the matrix of minimized interaction is given in Table 8.

Travel time in the system: Minimized Z = 10.481 min.

The overall 'minimized' interaction time in the system is 10.481 min as against the empirical travel time of 15.255 min.

This modeling approach is a bit very radical because it satisfies the requirements or demands of one zone completely before that of the next zone is satisfied. Like in the previous modeling efforts, the hallmark is still on travel time minimization. However, in urban goods movement, demand might not match supply as perfectly as Table 8 tends to suggest and this is one of the problems of applying automobile models to freight movement.

The major highlights of the linear programming minimized pattern of interaction (Table 8) is that it is mostly concerned with the micro-statistical distribution of trips within the system and not necessarily with trip ends. The model predicts that urban goods that emanate from Alagbaka should only be supplied to Alagbaka and Oja-Oba. For Ilesha road, the model predicts that the bulk of the goods should be absorbed within the zone, with the remainder going to Oja-Oba In the case of Oja-Oba, the model predicts that the goods should circulate within this zone, with little going to the residential zones. With regards to the residential zones, the model suggests that it is expedient for the goods generated within the zone to circulate also with the zone.

CONCLUSION

Urban goods movement is an area of urban transportation studies that has received only a scant attention. For example, there is a plethora of literature on urban passenger movement or public transport systems such as the mass-transit and the para-transit modes. There is also an abundance of literature on the relation between the urban trip origins and the landuse pattern of urban areas. Similar studies in the area of urban goods movement are generally lacking in urban transport literature, especially in Nigerian towns and in other cities in the developing countries.

This study has established the link between urban goods movement and land use typologies in Akure, Nigeria. This is of significant importance because most urban transportation planners generally overlook the influence of urban landuse pattern on the pattern of urban goods movement. The major findings of this study is that the commercial areas (Oja-Oba) made up of retail and wholesale activities; the public and semi-public landuses made up of State and Federal Government Secretariats, Head offices of Banks, assorted public organizations and institutions and the Ilesha road typified by industrial uses, manufacturing and sale of vehicle spare- parts constituted the major source regions of urban goods movement. The residential landuse elements ere the least generators of urban goods movement in Akure town.

With regards to the destination zones of urban goods movement, the study has been able to establish a link between urban goods movement and commercial land use (Oja-Oba), the industrial manufacturing zone (Ilesha road) and the public/semi-public landuse in Akure town. Again, the residential landuse elements had the least number of trip ends at the destination zones.

The optimization modeling approach using the linear programming approach that was adopted in the study gave a prediction of the micro-statistical distribution of urban goods in the system. The predicted zone-to-zone distribution of urban goods is based on the concept of travel time minimization. The shortcoming is that since the urban goods are not homogeneous in nature, a strict adherence to the predictions of the model might not satisfactorily match demand with supply. It provides a blind minimization travel-time without taking cognizance of the specific goods demanded by each of the regions.

This spurious allocation of urban goods trips by the optimization model brings to the fore the argument concerning the applicability of models developed for automobile/people transport to urban goods movement. Since the model was not originally developed for predicting urban goods movement, caution must therefore be exercised in implementing the model output.

The essence of predicting urban goods movement is predicted on its importance or utility in logistics planning. Freights movement especially raw materials in manufacturing industries and the distribution of manufactured goods rely on such concepts as the 'just-in-time' arrival of inputs and 'quick response' in retail supply of goods. The demand and supply chain logistics of freight movement could be appreciated and better understood through urban goods movement modeling. Where goods are to be delivered at home, urban goods modeling and routing could be invaluable. In this era of technology and internet, urban goods movement modeling would be a worthwhile contribution to the technology of Intelligent Transport Systems (ITS).

A thorough understanding of the pattern of urban goods movement will also assist in the efficient management of urban traffic. An understanding of the volume of urban goods movement can inform the allocation of some urban streets, especially at the central business district, to urban goods traffic. This would ease the problem of congestion in the urban traffic stream and ensure a smooth flow of urban traffic and keep pace with the just-in-time manufacturing in cities. The abatement of traffic congestion also has a special utility in ensuring air quality by reducing the emission of toxic fumes from the exhaust of vehicles. These toxic fumes include the various oxides of carbon and nitrogen. The oxides of carbon are particularly obnoxious because of their role in the green house effect and in the global warming phenomenon. Oxides of nitrogen and carbon are also well known for their roles in causing respiratory and pulmonary problems.

Future urban design efforts should endeavour to come out with an urban structure that will minimize travel time between production zones and consumption zones. Since the modeling effort was predicated on travel time minimization, it is expedient to ensure that the design of urban centers ensures a functional relationship between complementary landuses, to ensure an efficient flow of goods, at minimum time, in the urban areas.

In peroration, urban goods movement pattern still remains one of the least understood aspects of urban transportation planning. The challenges adumbrated above constitute research issues to be investigated and deciphered by interested researchers in this recondite field of study.

REFERENCES

Anderson, W.P., P.S. Kanaroglour and E.J. Miller, 1996. Urban Forum, Energy and the Environment: A Review of Issues, Evidence and PolicyUrban studies, 33: 7-35.

ASCE (American Society of Civil Engineers) Committee on Goods Movement, 1986. Issues and Problems of Moving Goods in Urban Areas. J. Transport. Eng., 115: 4-19.

Bourne, L.S, 1982. Internal structure of the city: Readings on urban form growth and policy. New York: (Oxford University Press).

Byrne, G.E. and S.M. Mulhall, 1995. Congestion Management Data Requirements and Comparisons. Transport. Res. Rec., 1499: 28-36.

Grainic, T.G. and G. Laporte, 1997. Planning Models for Freight Transportation. Euro. J. Operational Res., 97: 409-438.

DOT (US Department of Transport), 1995. Characteristics of urban freight systems Report. DOT-T-96-22, Office of Environment and Planning, Federal Highway Administration, Washington D.C.

Giles, D.L., 1997. Faster ships for the Future. Sci. Am., 277: 126-132.

Giuliano, G., 1989. Research Policy and Review 27: New Directions for Understanding Transportation and Land Use. Environ. Planning, 21: 145-159.

Ingram, G.K., 1998. Patterns of Metropolitan Development: What have we learned? Urban studied, 35: 1019-1035.

Metropolitan Toronto, 1987. Metropolitan Toronto Goods Movement Study: Technical Report. Roads and Traffic Department, Metropolitan Toronto.

NCHRP (National Cooperative Highway Research Program), 1995. Characteristics and Changes in Freight Transportation Demand. Project, National Cooperative Highway Research Program, Washington D.C., pp: 8-30.

Ogden, K.W., 1992. Urban Goods Movement: A Guide to Policy and Planning (London: Ashgate Publishing Ltd).

Okoko, E., 2002. Spatial Interaction Pattern in the Transport System in Akure Nigeria Unpublished Ph.D Thesis, Federal University of Technology, Akure, Nigeria.

Ortuzar, J. and L.G. Willumsen, 1994. Modeling Transport (Toronto: John Wiley).

Ruiter, R.J. 1992. Development of an urban truck travel model for the phoenix metropolitan Area. Report No. FHWA-AZ92-314, Arizona Department of Transportation, Phoenix.

TRANSPORT CANADA, 1979. UrbanGoods Movement Research: A framework and Results. Report TP 1834, urban transportation research branch of Canadian Surface Transportation Administration, Transport Canada, Ottawa.

Vancouver City Engineering Department, 1990. Truck study. Vacouver city Engineering Department, Greater Vancouver Regional District.

Woudsma, C., 2001. Understanding the Movement of Goods, Not people: Issues, Evidence and Potential. Urban studies, 38: 2439-2455.