Multimodal Transport System Effect on Logistics Responsive Performance: Application of Ordinal Logistic Regression

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Abstract

Multimodal transport system (MTS) and Logistics responsive (LR) performances are contemporary concepts in engineering and business disciplines respectively. However, their integration in transportation development is low, especially among developing nations, and therefore attracted few research interests. This paper aims at assessing the effect of MTS dynamics on logistics responsiveness and modal choices with the Ghanaian perception. Researchers adopted self-administered questionnaires and ordinal logistic regression approach. The study reviewed the broad-spectrum of logistics responsiveness, MTS dynamics, and status-quo of Ghanaian transport systems and afterwards analysed the opinions of a set of 500 respondents drawn from among transport practitioners and customers across all the ten regional capital cities in the country. It was underscored that efficient MTS development and management are crucial to reduce transport cost and improve logistics responsive trade-offs. Authors found that four modes (road, waterway, maritime and air), out of the five key transport systems studied, were statistically significant in influencing logistics responsiveness. Amazingly, rail system, despite its major role plays in MTS in an economy, was not statistically significant and therefore did not meaningfully influence LR. It was established in the study that the irregularity is in congruence with the peculiar Ghanaian situation as rail system is currently subjected to vicious cycle, hence contributed marginally to countrywide transport services. Notwithstanding the high cost and risks associated with air and road transport systems, they are the most preferred and well-developed transport options nationwide and this was again substantiated. Authors conclude that there is a significant influence of MTS dynamics on logistics responsiveness and has great impact on modal choices. Some strategies to improve MTS for satisfying logistics responsive demands are stressed. Researchers recommend that stakeholders should improve the expansion and integration of rail system into their MTS to achieve cost-efficient and logistics responsive goals.

*Keywords:*Logistics responsiveness, Multimodal transport system, Logistics performance, Modal choice, Ordinal logistic regression.

1. Introduction

Multimodal transport system and Logistics responsiveness are vital concepts in engineering and business disciplines respectively. However, the attention given to their

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integration in transport system developments by the scientific community is low, especially in developing countries and this has attracted few research attentions. The uncertainties in supply chain and market environments often create demand for responsive and efficient transport systems capable of moving freight and people from one point to another. There are various factors that influence transport mode choice, particularly in nations that have multiple transport modes or operate Multimodal transport systems.

Multimodal transport system (MTS) consists of a network of nodes (airport, seaport, and intermodal terminal) and links (road, rail, and navigable waterway), transit systems (inland terminals) and pedestrian walkways that are interconnected to constitute a seamless system for people and freight movements. When well-planned, maintained and managed, MTS can offer cost-effective, reliable, safe, speedy, energy-conserving, and environmental friendly means of transporting passengers and goods. There are many advantages of MTS that make it a good transport option for trade and industrial developments for nations. It reduces undue pressure on roads, ease congestion, limit travel times, improve passenger safety, and provide alternative transport routes for producers and consumers. By providing efficient and low cost services, MTS augments economic development and better the quality of life for people living in a society. Generally, the more viable transport system alternatives there are in a country, and the better the transport modes uniformly interlink and support each other, the less congestion and stressful there would be on all systems in the supply chain (Sheffi, 2005, Hamel and Valikangas, 2003, Hollnagel and Woods, 2006).

The terms multimodal, intermodal and combined freight transports are often used interchangeably (Islam et al., 2005). Combined transport is defined by the European Union Council directives 75/130/EEC as the transport of goods in which the conveying units; lorry, trailer, semi-trailer, swap body or container are conveyed by rail or waterway for part of the journey and road for the initial or terminal haul (Casaca and Marlow, 2007)(Markham, 1995). According to Macharis and Bontekoning (Macharis and Bontekoning, 2004), intermodal transport is defined as the use of two or more modes of transport in a single transport chain with no change of the transport unit for the freight with most of the routes trekked by rail, navigable waterway, or ocean going vessel and with the shortest likely initial and final distances travelled by road.

Basically, MTS comprises the use of more than one transport mode to successfully carry loads from one point to another. For example, coastal shipping, deep sea shipping, and inland waterway, as these often combine with road and/or rail to complete the shipment either at the beginning or the end of the shipment. These require uniform implement, complex software and good management techniques for an effective functioning as they operate in varieties of mode combinations. For instance, containers are uniformly designed (e.g. 20 footer or 40 footer containers) to carry cargoes by trains, trucks and ships within a single shipment in a MTS.

Comparatively, MTS is a better option to road-only and other unimodal transport systems as it has less technical problems, cost-efficient and more environmental responsiveness. It brings on board all the advantages of the combined modes. However, it receives less political support due to its high initial upfront construction costs and complex logistics infrastructure involvements, especially in less developed economies like that of Ghana.

The Council of Logistics Management (CLM, 1991) defined Logistics as the procedure of preparation, executing, and monitoring the well-organized, active movement and storing of cargoes, services, and interrelated information from source to destination in compliance with customer demands. Johnson and Wood (Johnson, 1996) explains logistics as a customer-oriented operation within supply chain management (SCM) as a procedure of conveying and managing freights and resources from the start to the finish of the manufacture, sale practice and waste removal, to fulfil consumers demands and increase commercial effectiveness (Tilanus, 1997). Therefore, logistics is a method of transporting and handling goods and materials from the start to the finish of a company's operations; production, distribution, sale process and waste disposal for industrial effectiveness and customers' satisfaction.

Transportation is the most crucial economic activity in logistics system as it occupies one-third to two-thirds of companies' logistics costs. As investigated by the National Council of Physical Distribution Management (NCPDM) (Temple and Sloane, 1982, Chang, 1998), the average transport costs 6.5% of market income and 44% of logistics cost. Hence, transport systems do not only make products timely deliverable but also responsive and useful under the least cost principle (Tseng et al., 2005). Without an effective transport system, logistics responsiveness as a customer-based operation management cannot attain its full advantages. Efficient transport system ensures improved logistics effectiveness, lessen operation cost and promote quality of service. The development of an efficient transport system requires the effort of the public as well as the private sectors to increase the competitiveness of government and enterprises.

Thus, transportation has fundamental responsibility in logistics responsiveness. Transport systems play dynamic and complex roles than the simple carrying of freights and people. It is only by means of well-managed transport and strategic systems assessment that passengers and freights can be moved to the right place, at the right time, at the right cost and ultimately meet customer's right logistics demands. By deduction, transportation in logistics management, is regarded as the pivot of efficiency, economy and expands other functions of logistics processes to bring expected benefits; service quality, competitiveness and responsive to customers and service providers (Lai et al., 2002, Lai et al., 2004).

The selection of transport modes affects logistics performances in organizations. Transport value and cost varies from industry to industry. For companies dealing with products of small volume, low weight and high value (e.g. jewellery companies), the cost of transport is low and less valued. However, firms dealing with products having large volume, heavy weight and low value (e.g. Cement industries) transportation costs and its effects on company profits are huge, and hence more regarded (Fair and Williams, 1981, Beuthe and Bouffioux, 2008, McGinnis, 1989). Transport system users need to investigate the system dynamics for efficient and responsive transport modes that can satisfy their demands. Similarly, transport service providers and stakeholders need to assess and improve their transport systems to remain competitive and sustainable in the industry and overall national socio-economic development.

Therefore, this research concentrated on companies that place much value and cost on transports in their logistics and supply chain operations with the ultimate goal of responsiveness and customer's fulfilment. The study also provides useful strategies for service providers on future transport systems.

It is worth knowing that different products transported by diverse companies require different focus on logistics responsiveness. For example, innovative products (e.g., smartphones) which reflect new trends are more focused on responsiveness than products that satisfy basic needs like fast-moving-consumer goods (FMCG) due to their volatile demand (Fisher, 2003). Hence, the responsiveness in logistics depends on anticipated uncertainty of demand which rely on effective planning capabilities and the inherent deviations in demand (Heikkilä, 2002). The management of supply chain and logistics responsiveness is crucial particularly when working in a competitive market environment which demands limited lead time and critical inventory (Aitken et al., 2003).

The choice of a transport mode in MTS to arrive at cost-efficient and effective-logistics responsiveness goals simultaneously is uneasily attainable and generally involves critical management trade-off decisions. Usually, the augmentations in logistics responsiveness are perceived to come at the expense of an upsurge in transportation cost to the disadvantage of customers or transport service providers. However, well-planned strategies and carefully selected transport systems can result in achieving responsiveness and cost-saving goals simultaneously to the satisfaction of most players within the supply chain.

Finding the strategic methods and influential factors in selecting appropriate cost-efficient transport system and attaining effective logistics responsiveness in unison are demanding tasks and these informed the researchers' decision in pursuing the study. Therefore, this research seeks to assess the influence of MTS dynamics on LR performance with evidence from Ghanaian perception. The assessment of the transport system characteristics and their influence on modal choice dynamics are among the objectives of the researchers.

The rest of the study is organized as follows. Section 2 reviews logistics responsiveness, influential factors in modal choice, transport system dynamics and the transport system situation in Ghana. Section 3 deals with materials and methods used for the research. Section 4 contains results and discussion and the final section 5 concludes.

2. Review of Logistics Responsiveness, Transport System Dynamics and Ghana transport system

2.1 Logistics Responsiveness

Responsiveness has globally become key objective in Logistics and Supply Chain Management (SCM) as a means of gaining market competitive edge. This concept in supply chains in meeting customer's dynamic demands and the management of an efficient MTS are current issues of key interests. There are several definitions of responsiveness in logistics and SCM. Frey (Frey, 1988) defined responsiveness as the capacity of a section within a company to respond to variations in customer requirements or in market situations. Kritchanchai and MacCarthy(Kritchanchai and MacCarthy, 1999) also defined it as the ability to react resolutely and within a suitable time-scale to customer claim or disparities in the marketplace, to bring about or maintain reasonable benefit. Stalk and Hout(Stalk Jr and Hout, 1990) emphasize on time-based rivalry and explain responsiveness as the consequences of executing a time-based approach.

Again, Barclay et al (Barclay et al., 1996) define responsiveness as the capability to react purposely and within a right period to significant procedures, chances or pressures especially from the outside environs to create or sustain competitive benefit. In another development, a responsive MTS is the one which stress on cost efficiency and flexible to unexpected customer's requirements such that no resources are misused on non-value added activities (Naylor et al., 1999). Furthermore, it is the skill to answer decisively and within an appropriate timeframe to customer's requests or changes in the market place, to generate or sustain reasonable benefit (Holweg, 2005).

Logistics Responsiveness is therefore defined as the ability of a firm to strategize and manage its logistics system to deliberately satisfy with unpredictable customers' requirements. It aims at synchronizing the transport and other logistics activities to optimize the capacity to manage with the dynamic customer demands (Bhatnagar and Teo, 2009, Audy et al., 2012).

There are key factors for considerations in selecting a particular transport mode for the movement of passengers (commuting) or the delivery of goods (freight). Some key features passengers consider for specific travel modes are accessibility, cost, safety, reliability, speed, privacy and comfort (Chee and Fernandez, 2013). The normally preferred mode choices by customers are automobile, public transit, inland and coastal water, walking, and bicycling due to such factors including economic constraints, disabilities, and personal preferences. For instance, the increases in fuel prices make commuters prefer public transport or carpooling to minimize transport cost. Land development patterns and availability of transport alternatives are other influential factors. Mode choices are also affected by congestion pricing, tolling, and other demand management strategies (Ghani et al., 2007).

In consideration for freight transport, commercial carriers mostly prefer routes and transport systems that allow for the best blends of speed, cost, volume, reliability, and service quality that are more responsive to customers' demands. The factors that influence freight shipments are shipment size, value of product, weight, travel distance, packaging requirements, product perishability, and hazardous material content. Transportation network characteristics like infrastructure availability, congestion levels, and transport mode regulations are equally important factors for mode choice. Freight movement is also determined by carrier market attributes such as availability and competition (Joewono and Kubota, 2007).

The various transport elements bring about uncertainty in customers' demand and determines the optimal transport systems that are more responsive to satisfy such unpredictable requirements. For instance, customers having freight of higher value to weight ratios, and less than 500 miles travel distances usually prefer the use of short transport modes such as roads. Contrariwise, shipments with lower value to weight ratios and longer haul distances mostly select long but low-cost transport modes like rail, and waterway. For shipment to be more responsive and cost efficient, multimodal transport modes are required to combine the cost or speed benefits of individual constituent modes. Usually, water, rail or air transport modes combine with the pickup and delivery convenience of truck mode to ensure efficient and responsive MTS. The use of land transport like truck, pipeline and rail modes are sensitive to many variables like levels of economic activities, fuel price changes, transport mode choices and demographic factors.

2.2 Dynamics in Multimodal transport system

There are different types of transport systems; maritime (sea), air transport, inland navigable waterway and land (road, rail, pipeline) with each having varying features. Based on the existing literatures and findings from the contacted expert transport practitioners, the following transport system dynamics were determined and their unique characteristics stated in Table1.

Table 1: Transport System Dynamics

Transport system Characteristics	*Advantages*	*Disadvantages*	*Development Strategies*
Maritime Logistics Main types (3); . Liner . Tramp . Industry	Cheaper transport cost . High carrying capacity . Mostly transport goods like crude oil and dry bulk cargo e.g. grains	. Takes Longer transport time . Schedules are affected by weather conditions	. Needs large-scaled ships .Requires cooperative techniques. .Build innovative logistics concepts; . real-time information . accurate time windows . freights tracking systems
Air transport Aviation .Airplanes & Airports are separated, hence need planes . Speed delivery at far distances	. Highest speed .Lower risk of damage, . High security, . Flexibility, . Accessibility .Frequent and regular to destinations .very Suitable for passenger's movements. .unaffected by land forms	. High delivery fee, .Weather conditions may affect its operations . Environmental pollution . Not suitable for conveying heavy goods due to its cost.	Chosen when the cost per unit mass of consignments is high and conveyance time is a key factor. connect with other modes; Internationalization, Form cooperation and merger with air transport establishments, Cooperate with other modes; maritime, land for door-to- door& JIT services (Reynolds-Feighan and Feighan, 1997, Reynolds-Feighan, 2001).
Waterway system Navigable rivers and lakes	. Cheaper delivery costs .Environmental friendliness . Cheaper Route construction costs.	.Slower time delivery . Accessible only at places where there are rivers and lakes	Countries with rivers and lakes resources can invest in developing them into navigable waterways to support multimodal transport system.
Road system Major Land transport system. Mostly form part of MTS. It usually connect terminals ; begins and ends the system	Extends delivery services by linking airports to seaports with or without rail in MTS. .Cheaper to invest in it. .Door-to-door services. .High accessibility .Flexibility, Availability	.Less capacity .Lower safety .Slower speed .Excess usage causes; traffic jams, accident, Pollutions, etc.	Revolution in transport policies and management controls is needed; pricing, tolling, levies
Pipeline system . Mostly for fluid products; liquids and gases e.g. oil and gases	. Great volume . Less effect by weather conditions . lower operation fees Constant conveyance.	.Expensive setups cost . Harder supervision . Goods specialization . Risks of theft and pipe damages .Regular maintenance	.Innovate means of integrating into the multimodal transport system. .Collaboration of companies for establishment.
Rail system Part of land transport and often joins ports (seaport or airport) to transit terminals.	. High carrying capacity . less effect with weather situations . Lower fuel consumption	. High cost of facilities .Expensive maintenance . Lack of elasticity of urgent demand . Much time is spent in organizing carriages	. Construction of inland ports to link rail to ports and roads or waterways. . Government require the Collaboration of financiers and investors to build Railways.

Multimodal Transport Systems (MTS) . Rail –road .Waterway-road .Air-road .Rail- waterway .Combinations of other Feasible modes.	Combines all the advantages of each interlinked modes to be responsive and satisfy customers' demands: . speed . accessibility . reliability, . capacity, . flexibility, .cost benefits, etc.	.High initial setup capital involved . Management of operations are demanding as it involves multiple modes and various players	. Needs political support; Requires policies to motivate operators, . Investors and financiers collaborations are needed . Requires Public-Private-partnership (PPP) . Attracting and training of skilled labour for competent management . Future trends demand door–to-door, efficiency, traceability, JIT, and regular routing services

2.3 Transport systems in Ghana

The World Bank's Global Rankings, 2016 rated Ghana as the 88th performer, out of 160 nations on the Logistics Performance Index (LPI) conducted in 2016. The assessment with its regional peers, Ghana's LPI and custom procedures are better. LPI is the global improvement of ranking in international shipments, based on competence and logistics quality (WB, 2016)(Hanaoka and Regmi, 2011).

Ghana places itself as the safe gateway to West Africa. Transportation is the valuable infrastructure segment that promotes socio-economic development. The Ghana Ministry of Transport (GMoT) was established in 2009 by re-aligning the functions of the former existing ministries of Aviation, Harbours, Railways and the Road Transport Services. The integration was to form a combined, economical, secure, and viable transport system responsive to the needs of society, supportive to development and poverty reduction and proficient of instituting Ghana as a transport hub of West Africa. The Ghana Shared Growth Development Agenda (GSGDA) (Growth, 2012) has seven policy aims that are central to the GMoT as follows:

- Inaugurate Ghana as a transport center for West African sub region,
- Generate and withstand an effective transport system that guarantees user needs,
- Integrate land use, transport scheduling, development planning and service delivery,
- Make a lively asset and conducive management setting that optimize benefits for private and public sector investors,
- Grow and implemented all-inclusive and integrated policy, governance and established frameworks,
- Guarantee maintainable expansion in the transport sector,
- Train human resources to apply new skills (GHA, 2016).

The Price Water house and Coopers (PWC) report also congratulated Ghana for being one of the world's rapidly growing economy and having transport infrastructure systems connecting the next-door states that make it serve as a convenient entrance to West African markets. Imports and exports trading forms major part in Ghana's fiscal growth by 44% and 50% respectively (PWC, 2016).Table 2 summarizes the main transport system situation in Ghana.

Table 2: Transport systems in Ghana

Transport System	*State of development*
Road transport	Road is the main mode of transport in Ghana. It accounts for 94% of freight and 97% of passenger traffic movements. Ghana had improved its road networks since 1990s. This has led to its emergence as a hub connecting the entire West African trade zone. Ghana's road network is estimated to be 67,291km(GHA, 2016) . It consists of trunk, feeder and urban roads. The over-reliance on road has raised many issues like GHG pollutions, congestion and accidents. Government spends about 1.5 % GDP yearly on roads.
Waterway transport	It operates on the Volta Lake transport system which extends around 450km from the south to the north with ports located at Yapei, Buipe, Akosombo and and major ferry crossings at Kpandu, Dambai, Yeji and KetaKrachi. It transports petroleum products such as cement, agricultural commodities and also offer passenger services along the lake. Barge transport has economic advantages; supports trucking, limits overloading, reduce traffic congestion and lowers maintenance costs on roads. Other routes are specific to small towns using boats and canoes to operate on Ankobra, Pra, Oti, Black Volta, White Volta, and Lake Bosomtwi. It gives cheaper options to rail and road for the northern and southern part of Ghana. Waterway transport emits less GHG pollutants.
Rail transport	Unlike before, Rail freight and passenger traffic are now insignificant in Ghana. It manages less than 2% of freight and about 1% of passenger traffic. (GPHA, 2015) Currently, it is facing vicious cycle. However, Rail has the potential of occupying a vital position of Ghana's future multimodal transport system and a feasible option to road on the demanding transport corridors. There are plans to develop and expand the railway network to help in transporting the unindustrialized oil and gas. Ghana plans to expand the existing railway network from the South to the North to link Ghana to its neighbors; Burkina Faso, Niger, Mali, Cote d'Ivoire and Togo. Another plan is to link Tema to Akosombo to promote multimodal (rail-Volta Lake) transport (GPHA, 2015).
Air transport	It is a growing industry that provides crucial air transport services within Ghana. It links Ghana to the sub-region and other parts of the world. Ghana has 8 developed airports each located at 8 out of the 10 regional cities including international airports that make it emerge as a safe gateway and transport hub in the West African trade zone. Kotoka International Airport (KIA) is located at the capital and it is the main international airport in Ghana. Most of the nation's air transport market is international and grouped under intra-African and intercontinental flights, mostly for passengers.
Pipeline Transport	Pipeline sector is now under-construction by the West African Pipeline Project. The aim is to exchange natural gas from Nigeria through Benin and Togo to this country. It transports petroleum products from Tema Port to Akosombo. Plans are advanced to increase it to cover other parts of the country.
Maritime Transport	Ghana plans to make its ports a maritime hub for West Africa and beyond. The Domestic maritime trade is served by two ports: Tema port, located at around 25km east of Accra, the capital; and Takoradi situated at 230km to the west. The two ports handle more than 90% of export and import trade activities. Tema port serves as an outlet for Ghana's landlocked neighbors; Burkina Faso, Niger, and Mali whereas Takoradi serves the rapidly growing offshore gas and oil fields. The ports serve local production and international traders. The services managed at the ports are shore and vessel handlings, stevedoring, transit storage facilities and related services to vessels and cargo. The recent increase in demand has led to congestion and capacity constraints as evidenced in long lines of vessels at the ports' entrances It is therefore evident that Ghana has the potential resources to improve multimodal transport system by efficiently interconnecting the various modes of transport.

3. Materials and Methods

Prior to the preparation of the survey questionnaire, some transport experts and practitioners were contacted for information on essential elements that constitute modal choice, MTS dynamics, and transport logistics responsiveness. Their contributions together with the reviewed literatures profoundly informed researchers on MTS dynamics and the design of the questionnaire instrument.

3.1 Sampling strategy and sample size

In choosing the sample size of practitioners involved in transportation, the researchers employed stratified random sampling technique(Cochran, 2007, Kothari, 2004). A sample size of 500 respondents were selected across all the ten regional capital cities of Ghana. By doing so the cities with larger number of companies with practitioners engaging in more transport activities are given greater sample sizes than the cities with lesser number of firms with practitioners involved in less transport operations. The method considered each region's population of respondents as a stratum. Afterwards a simple random sampling technique (Marshall, 1996, Patton, 2005) was used to select customers as depicted in Table 3.

Table 3: Respondents from the selected cities

City	*Strata Sample Size*
Accra	100
Koforidua	40
Takoradi	100
Cape Coast	40
Kumasi	100
Ho	20
Sunyani	30
Tamale	30
Wa	20
Bolgatanga	20
Total	500

Source: Researchers' field survey, 2016

3.2 Structure of Questionnaire

The work used self-administered questionnaires to gather data from respondents. Firstly, respondents were requested to answer questions relating to their demographic characteristics and secondly required their ratings on key MTS in respect of logistic responsiveness. In all, the questionnaire has seven components, comprising of questions relating to respondents' demographic data, road transport, rail transport, waterway transport, maritime transport, air transport and logistics responsiveness. In the questionnaire 15 modal choice factors or characteristics were stated under each transport system that sought respondents' perceptions and evaluations MTS on logistics responsiveness.

These parametric factors are average delivery cost rate, average lead time delivery, risk of cargo damage/lose, capacity adequacy, infrastructure network availability, security and safety response issues, speed of response to information, service reliability, access to tracking services, energy efficiency, environmental impact, flexibility and door-to-door services, variety/multiple freight transport services, frequent accessibility to destinations and overall service quality.

Similarly, there were ten corresponding parameters for evaluating logistics responsiveness which requested customers to rank in a Likert scale the transport system that; meet their quality standards, reduce product delivery cycle time, decrease operation cost, rely on effectiveness of suppliers, give quick response, respond to customer changing needs, make good use of resources, are environmentally safe, increase returns on assets, and transport varieties of freights.

3.3 Model specification, estimations and Tests

There have been many established methods for investigating the several possibilities in view of Likert scale responses with many possible options. The best fitting method for this study is the adoption of the ordinal logit concept (Agresti, 2002) and (Gelman and Hill, 2007).

The fundamental principle of the ordinal logit model (Abdul-Rahaman, 2016) is re-stating the categorical variable in terms of various binary variables grounded on internal cut-points in the ordinal scale. The notations used in the model are as follows;

Let Y denotes a random variable which can assume a unit K discrete values (i.e., fall within K classes.

- Number the classes 1… K.
- Thus, $\pi_{i2} = \Pr(Y_i = 2)$ represents the probability that the ith individual's product fits the second class.
- Mostly, $\pi_{ik} = \Pr(Y_i = k)$ represents the probability that the ith individual's outcome belongs to the kth class.

Otherwise when the groups are organized to assume that the log odds of $Y \geq k$ is linearly connected with the predictor variables.

This is commonly known as the proportional odds (Clogg and Shihadeh, 1994).

The model is therefore given by

$$\log\left(\frac{\pi_k + ... + \pi_K}{1 + ... + \pi_{k-1}}\right) = \beta_{0k} + X^T \beta \tag{1}$$

Thus, we need to estimate $K-1$ intercepts, but only p linear effects, where p denotes the number of explanatory variables (i.e. $K + p - 1 < (K-1)(p+1)$, if $K > 2$).

3.3.1 Testing parallel lines

As said by Lao,(Liao, 1994), the Chi-square is mostly used to find the variance among two-2log-likelihood figures. If the lines are parallel, the observed significance value for the change would be large, since the general model does not improve the fit very much and therefore the parallel model is said to be adequate. The study will test the following hypothesis;

- H0: The location parameters (slope coefficients) are the same across response groups.
- H1: The location parameters (slope coefficients) are not the same across response groups.

3.3.2 Goodness-of-fit test

With the observed and anticipated frequencies, the usual Pearson and Deviance goodness-of-fit measures can be computed. Usually, Pearson and Deviance goodness-of-fit measures can be calculated [49].

The Pearson goodness-of-fit statistic is

$$\chi^2 = \sum\sum\left(\frac{O_{ij} - E_{ij}}{E_{ij}}\right)^2 \tag{2}$$

And the Deviance measure is

$$D = 2\sum\sum O_{ij} In\left(\frac{O_{ij}}{E_{ij}}\right) \quad (3)$$

The following hypothesis are tested here;

- H0: The fitted model is consistent with the observed data.
- H1: The fitted model is not consistent with the observed data.

For a well fitted model, the observed and anticipated cell counts are similar, the value of each statistic is small, and the observed significance level is large(Ananth and Kleinbaum, 1997).

We reject the null hypothesis that the model fits, if the observed significance level for the goodness-of-fit statistic is small (O'Connell, 2006). Models with large observed significant levels are good models (Ananth and Kleinbaum, 1997), (O'Connell, 2006).

3.3.3 Overall model test

According to Liao (Liao, 1994) and Paul (Paul, 1999) a change in likelihood function has a chi-square distribution even when there are cells with small observed and predicted counts.

The null hypothesis that the model without predictors is as good as the model with the predictors can be meant to be rejected when it is observed that the difference between the two log-likelihoods-the Chi square-has an observed significance level smaller than 5% (Liao, 1994), (Paul, 1999).

The hypothesis test here is given by;

- H0: The model without predictors is as good as the model with the predictors.
- H1: The model without predictors is not as good as the model with the predictors.

3.3.4 Test of strength of association

There are many R2 –like statistics that can be used to measure the strength of association between the dependent and the independent variables and the predictor variables. But they are not as beneficial as R2 statistic in regression, since their interpretation is not straightforward. The three commonly used statistics are;

Cox and Snell's R2,

$$R^2_{RC} = 1 - \left(\frac{L\left(B^{(0)}\right)}{L(\hat{B})}\right)^{2/n} \quad (4)$$

Nagelkerke's R2,

$$R^2_N = \left(\frac{R^2_{CS}}{1 - L(B^{(0)})^{\frac{2}{n}}}\right) \quad (5)$$

McFadden's R2,

$$R^2_M = \left(\frac{L(\hat{B})}{L(B^{(0)})}\right) \quad (6)$$

4. Results and Discussion

It can be seen in Table 4 that the p-value (0.167) is more than the margin of error (0.05). This signifies that we fail to reject the null hypothesis that the fitted model is consistent with the observed data. Thus,we accomplish that the fitted model is good, in particular the data used in this study is at 95% confidence level, signifying a good model.

Table 4: Goodness–of–Fit Test

	Chi-Square	*Df*	*p-value*
Pearson	76743.651	646	0.167
Deviance	490.528	646	0.989

The R-squared (Nagelkerke=89.7%) in Table 5 shows that the independence variables (transport systems) explains most of the proportions of variation in the dependent variable (logistics responsiveness). However, there is around 10.3% of the variability which is uncounted for, which may be due to research related errors.

Table 5: Pseudo R-Square Figures

Cox and Snell	*Nagelkerke*	*McFadden*
0.846	0.897	0.653

Test of parallel lines are used to check for the hypothesis that the regression coefficients are equal for all groups. To reject the hypothesis of parallelism, we would apply multinomial regression, which assesses distinct coefficients for respective group. Because the perceived significance level in Table 6 is large (i.e. p>0.05), infers that there is not enough evidence to reject the parallelism hypothesis. Hence, we conclude that the regression coefficients are the same across the response groups.

Table 6: Test of parallel lines

Model	*-2 Log Likelihood*	*Chi-Square*	*df*	*sig.*
Null Hypothesis	492.474			
General	100.352	492.474	116	0.997

In order to examine the individual coefficients, a total examination of the null hypothesis that the location coefficients for all the variables in the model are zeromust be established. Therefore, it can be realised from Table7that the variance between the two log-likelihoods with Chi-square distribution has a perceived significance level of less than 0.05 (P <0.05). Meaning the null hypothesis that, the model without predictors is as good as the model with the predictors, would be rejected. Therefore, the model without predictors is not as good as the model with the predictors.

Table 7: Model fitting information

Model	*-2LogLikelihood*	*Chi-Square*	*Df*	*Sig.*
Intercept only	1429.299			
Final	492.474	936.824	29	0.000

It can be appreciated from Table 8 that four out of the five key transport modes under study were statistically significant in influencing logistic responsiveness in Ghana. These key transport systems in their descending order of impacts are road, waterway, air, and maritime. Meanwhile, respondents who agree to road transport system are more expected to allocate higher scores to logistic responsiveness than their counterparts who disagree. Also, respondents who agree on maritime transport system are more likely to allot higher ratings for logistic responsiveness in Ghana than those who reason differently.

Table 8: Ordinal logistic regression

Transport Logistics Variables	*System and Responsiveness*	*Estimate*	*Std. Error*	*Wald*	*df*	*sig.*	*95%Confidence Interval Lower Bound*	*Upper bound*
Dependent	[Logistic Resp = 1]	-11.686	2.000	34.150	1	0.000	-15.605	-7.766
	[Logistic Resp = 2]	-6.829	1.893	13.015	1	0.000	-10.539	-3.119
	[Logistic Resp = 3]	-5.360	1.859	8.311	1	0.004	-9.004	-1.716
	[Logistic Resp = 4]	.573	1.851	.096	1	0.757	-3.054	4.200
	[Logistic Resp = 6]	9.796	1.963	24.896	1	0.000	5.948	13.644
Independent	[Road=1]	-2.656	.970	7.501	1	0.006	-4.556	-.755
	[Road=2]	-6.137	.838	53.672	1	0.000	-7.778	-4.495
	[Road=3]	-4.179	.968	18.616	1	0.000	-6.077	-2.280
	[Road=4]	-1.231	1.220	1.019	1	0.013	-3.622	1.160
	[Road=5]	-5.879	.896	43.097	1	0.000	-7.635	-4.124
	[Road=6]	-3.105	.805	14.885	1	0.000	-4.683	-1.528
	[Road=7]	0[a]	.	.	0	.	.	.
	[Rail=1]	.789	.845	.873	1	0.350	-.866	2.445
	[Rail=2]	2.358	.862	7.492	1	0.006	.670	4.047
	[Rail=3]	1.253	.700	3.202	1	0.074	-.119	2.626
	[Rail=4]	-.014	.793	.000	1	0.986	-1.568	1.540
	[Rail=5]	-1.873	.786	5.674	1	0.017	-3.414	-.332
	[Rail=6]	.292	.793	.136	1	0.712	-1.261	1.846
	[Rail=7]	0[a]	.	.	0	.	.	.
	[Maritime=1]	.579	1.710	.114	1	0.735	-2.774	3.931
	[Maritime=2]	1.006	1.018	.976	1	0.323	-.989	3.001
	[Maritime=3]	3.451	1.252	7.602	1	0.006	.998	5.904
	[Maritime=4]	-1.009	.904	1.247	1	0.264	-2.780	.762
	[Maritime=5]	5.026	1.052	22.835	1	0.000	2.964	7.087
	[Maritime=6]	-.261	.960	.074	1	0.006	-2.143	1.620
	[Maritime=7]	0[a]	.	.	0	.	.	.
	[Waterway=1]	28.791	.000	.	1	.	28.791	28.791
	[Waterway=2]	-.727	.930	.612	1	0.004	-2.550	1.095
	[Waterway=3]	.249	.917	.074	1	0.006	-1.549	2.047
	[Waterway=4]	-2.066	.932	4.909	1	0.027	-3.893	-.238
	[Waterway=5]	.830	1.200	.478	1	0.009	-1.522	3.182
	[Waterway=6]	-1.824	.968	3.548	1	0.000	-3.721	.074
	[Waterway=7]	0[a]	.	.	0	.	.	.
	[Air=1]	0[a]	.	.	0	.	.	.
	[Air=2]	.970	1.230	.621	1	0.431	-1.442	3.382
	[Air=3]	.838	1.244	.454	1	0.050	-1.599	3.276
	[Air=4]	-3.693	1.234	8.956	1	0.003	-6.111	-1.274
	[Air=5]	2.098	1.172	3.206	1	0.013	-.198	4.395
	[Air=6]	1.926	.656	8.618	1	0.003	.640	3.213
	[Air=7]	0[a]	.	.	0	.	.	.

Again, respondents who agree on the value of water transport system are more likely to assign high ratings for logistic responsiveness than those who disagree. Moreover, respondents who agree on the dimension of air transport system have the likelihood of assigning higher ratings for logistic responsiveness in Ghana than their counterparts who just disagree.

However, rail transport system despite its major role in MTS as stated by various authors was not statistically significant in this study. This means that rail mode of transport does not importantly influence or affect the logistic responsiveness in the Ghanaian economy. This irregularity is in the agreement with the peculiar Ghanaian situation as rail transport system is now experiencing vicious cycle by contributing to only 1% passenger and 2% freight movements in the nation as stated earlier on in the literature (GPHA, 2015, GPHA, 2016).

Again, among the various factors captured in the study, road system is the commonly used mode of transport for both passengers and freights. The combination of road and air as a MTS is the popularly chosen for the most responsive logistics system. The reason is that these systems have efficient and well developed infrastructures (nodes and links) in the nation compared with other means of transport. Thus, supporting the literature that the accessibility of well developed and managed MTS promote logistics responsiveness (PWC, 2015, PWC, 2016, GHA, 2016)(Giannopoulos, 2009).

5. Conclusion

The authors conclude that there is a significant influence of MTS dynamics on logistics responsiveness and this has momentous impact on transportation modal choices.The study assessed multimodal transport system dynamics and their influence on logistics responsiveness. It covers broadly the various transport modes that constitute multimodal systems in Ghana similar to most developing nations and the influential factors that constitute modal choice for customers to achieve their logistics responsive aspirations. It was discovered that efficient MTS is indispensable in transport cost reduction and logistics responsiveness, and needs the support of governments and transport service providers. The common factors for transport system assessment examined are availability, reliability, flexibility, speed, capacity, and cost benefits.

It was realised that freight transported in Ghana use variety of modes such as truck, air, water, rail, pipeline and combinations of two or more to form multimodal systems. Out of the major transport systems studied, four modes; road, maritime, water and air were significant contributors to logistic responsiveness. However, rail system did not significantly affect the logistics responsiveness in the Ghanaian economy. Again, the arrangement of road and air as MTS in Ghana is the popular choice for the most responsive logistics system. However, considering the high costs and environmental risks associated with these transport modes, future MTS developments have to improve on the incorporation of less cost and more environmental friendly modes like rail and waterway systems for the trade-off for accomplishing cost-efficient and logistics responsive goals. The study therefore recommends the intervention of stakeholders to develop railway system in the country as rail functions in any effective multimodal system in every economy cannot be downplayed in achieving cost-saving, environmental sustainability and logistics responsiveness aspirations.

This paper will serve the benefits of all concern stakeholders; customers on mode choice, government on transport system planning and development, transport providers, academicians and researchers. Again, it will suggestively add up to the body of knowledge on the subject matter. Future studies will consider MTS mechanisms and optimisation models for integrating multiple transport modes to attain cost efficiency and logistics responsiveness simultaneously.

References

Abdul-Rahaman, A.-A. (2016). “Modelling Customer Satisfaction at Ghana Commercial Bank: An Application of Ordinal Logit Regression”, *Journal of Research in Business, Economics and Management,* 5**,** 670-677.

Agresti, A. (2002). “Categorical Data Analysis”,*New Jersey: John Willey and Sons. Inc.*

Aitken, J., Childerhouse, P. & Towill, D. 2003. “The impact of product life cycle on supply chain strategy”,*International Journal of Production Economics,* 85**,** 127-140.

Ananth, C. V. & Kleinbaum, D. G. (1997). “Regression models for ordinal responses: a review of methods and applications”,*International journal of epidemiology,* 26**,** 1323-1333.

Audy, J. F., Lehoux, N., D'amours, S. & Rönnqvist, M. (2012). “A framework for an efficient implementation of logistics collaborations”,*International transactions in operational research,* 19**,** 633-657.

Barclay, I., Poolton, J. & Dann, Z. (1996). “Improving competitive responsiveness via the virtual environment”,*Engineering and Technology Management*. IEMC 96. Proceedings., International Conference on, 1996. IEEE, 52-62.

Beuthe, M. & Bouffioux, C. (2008). “Analysing qualitative attributes of freight transport from stated orders of preference experiment”,*Journal of Transport Economics and Policy (JTEP),* 42**,** 105-128.

Bhatnagar, R. & Teo, C.-C. (2009). “Role of logistics in enhancing competitive advantage: A value chain framework for global supply chains”,*International Journal of Physical Distribution & Logistics Management,* 39**,** 202-226.

Casaca, A. C. P. & Marlow, P. B. (2007). “The Impact of the Trans-European transport networks on the development of short sea shipping”,*Maritime Economics & Logistics,* 9**,** 302-323.

Chang, Y. (1998). “Logistical Management”,*Hwa-Tai Bookstore Ltd., Taiwan*.

Chee, W. L. & Fernandez, J. L. (2013). “Factors that influence the choice of mode of transport in Penang: a preliminary analysis”,*Procedia-Social and Behavioral Sciences,* 91**,** 120-127.

CLM. (1991). “*Council of Logistics Management* [Online]. Available: https://www.britannica.com/topic/Council-of-Logistics-Management [Accessed 12/04/2017.

Clogg, C. C. & Shihadeh, E. S. (1994). “Statistical models for ordinal variables, *Sage Publications, Inc*.

Cochran, W. G. (2007). *Sampling techniques,* John Wiley & Sons.

Fair, M. L. & Williams, E. W. (1981). *Transportation and Logistics,* Business Publications, Incorporated.

Fisher, M. L. (2003). “What is the right supply chain for your product”,*Operations management: critical perspectives on business and management,* 4**,** 73.

Frey, E. (1988). “The evolution of performance measurement”,*Industrial Management***,** 9-12.

Gelman, A. & Hill, J.(2007). “Data analysis using regression and multilevelhierarchical models”,*Cambridge University Press New York*, NY, USA.

GHA. (2016). *Environmental and Social Assessments* [Online]. Ghana Highways Authority(GHA). [Accessed 21/09/2017.

Ghani, M. N. N., Ahmad, M. Z. & Tan, S.-H. (2007). "Transportation Mode Choice: Are Latent Factors Important? Proceedings of the Eastern Asia Society for Transportation Studies The 7th International Conference of Eastern Asia Society for Transportation Studies",*Eastern Asia Society for Transportation Studies*, 124-124.

Giannopoulos, G. A. (2009). "Towards a European ITS for freight transport and logistics: results of current EU funded research and prospects for the future",*European Transport Research Review*, 1**,** 147-161.

GPHA. (2015). *Ghana Ports Handbook* [Online]. Available: https://issuu.com/landmarine/ docs/ghana_ports_handbook_2016-17 [Accessed 27/11/2016.

GPHA. (2016). *Performance Statistics of Tema Port* [Online]. Ghana Ports and Harbors Authority. Available: http://www.ghanaports.gov [Accessed 21/10/2016.

Growth, G. S. (2012). Development Agenda (GSGDA) 200–2013. "Medium Term and National Development Policy Framework: Government of Ghana", *National Development Planning Commission (NDPC),* 1.

Hamel, G. & Valikangas, L. (2003). "The quest for resilience",*Harvard business review,* 81**,** 52-65.

Hanaoka, S. & Regmi, M. B. (2011). "Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective",*IATSS Research,* 35.

Heikkilä, J. (2002). "From supply to demand chain management: efficiency and customer satisfaction",*Journal of operations management,* 20**,** 747-767.

Hollnagel, E. & Woods, D. D. (2006). "Epilogue: Resilience engineering precepts",*Resilience Engineering–Concepts and Precepts, Ashgate, Aldershot***,** 347-358.

Holweg, M. (2005). "The three dimensions of responsiveness",*International Journal of Operations & Production Management,* 25**,** 603-622.

Islam, D. M. Z., Dinwoodie, J. & Roe, M. (2005). "Towards supply chain integration through multimodal transport in developing economies: The case of Bangladesh",*Maritime Economics & Logistics,* 7**,** 382-399.

Joewono, T. B. & Kubota, H. (2007). "Exploring public perception of paratransit service using binomial logistic regression",*Civil Engineering Dimension,* 9**,** pp. 1-8.

Johnson, J. (1996). *Contemporary Logistics*. 6 th.

Kothari, C. R. (2004). "Research methodology: Methods and techniques",*New Age International*.

Kritchanchai, D. & Maccarthy, B. L. (1999). "Responsiveness of the order fulfilment process",*International Journal of Operations & Production Management,* 19**,** 812-833.

Lai, K.-H., Ngai, E. & Cheng, T. (2002). "Measures for evaluating supply chain performance in transport logistics",*Transportation Research Part E: Logistics and Transportation Review,* 38**,** 439-456.

Lai, K.-H., Ngai, E. & Cheng, T. (2004). "An empirical study of supply chain performance in transport logistics",*International journal of Production economics,* 87**,** 321-331.

Liao, T. F. (1994). "Interpreting probability models: Logit, probit, and other generalized linear models",*Sage*.

Macharis, C. & Bontekoning, Y. M. (2004). “Opportunities for OR in intermodal freight transport research: A review”,*European Journal of Operational Research,* 153**,** 400-416.

Markham, J.(1995). “The European railways perspective”,*World Transport Policy and Practice,* 1**,** 28-33.

Marshall, M. N. (1996). “Sampling for qualitative research”,*Family practice,* 13**,** 522-526.

Mcginnis, M. A. (1989). “A comparative evaluation of freight transportation choice models”,*Transportation Journal***,** 36-46.

Naylor, J. B., Naim, M. M. & Berry, D. (1999). “Leagility: integrating the lean and agile manufacturing paradigms in the total supply chain”,*International Journal of production economics,* 62**,** 107-118.

O'connell, A. A. (2006).“Logistic regression models for ordinal response variables”,*Sage*.

Patton, M. Q.(2005). *Qualitative research*, Wiley Online Library.

Paul, D. (1999). “Logistic regression using the SAS system: theory and application”,*SAS Institute Corp., USA.*

PWC. (2015). *Africa Infrastructure Investment:Ghana* [Online]. Ghana-Price Waterhouse Coopers. Available: . https://www.pwc.com/gx/en/transportation-logistics/publications/africa-infrastructure-investment/assets/ghana.pdf [Accessed 22/12/2016.

PWC. (2016). *Africa Gearing up Report* [Online]. Available: http://www.pwc.com [Accessed 22/12/2016.

Reynolds-Feighan, A. J.(2001). *Air freight logistics*, UK, Elsevier Science Ltd.

Reynolds-Feighan, A. J. & Feighan, K. J.(1997). “Airport Services and Airport Charging Systems: A Critical Review of The EU Common Framework1”,*Transportation Research Part E: Logistics and Transportation Review,* 33**,** 311-320.

Sheffi, Y.(2005). “The resilient enterprise: overcoming vulnerability for competitive advantage”,*MIT Press Books,* 1.

Stalk Jr, G. & Hout, T. M. (1990). “Competing against time”,*Research-Technology Management,* 33**,** 19-24.

Temple, B. & Sloane(1982). “Transportation strategies for the eighties”, *Oak Brook, IL (2803 Butterfield Rd., Oak Brook 60521), National Council of Physical Distribution Management.*

Tilanus, B. (1997). “Information systems in logistics and transportation”,*Pergamon London.*

Tseng, Y.-Y., Yue, W. L. & Taylor, M. A.(2005). “The role of transportation in logistics chain”,*Eastern Asia Society for Transportation Studies*.

WB. (2016). *International LPI Global Ranking* [Online]. The World Bank. Available: http://lpi.worldbank.org/international/global/2016 [Accessed 02/03/2017.

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