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Feasibility study for the introduction of synchromodal freight transportation concept

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Abstract: The current weaknesses of the conventional intermodal freight transportation system have led to the development of the synchromodal freight transportation concept introduced and piloted in the Netherlands. The innovative concept has the advantage of adding flexibility, cost reduction, and sustainability among other things, into the freight transportation system. The synchromodal system has not been started in any developing country yet due to its newness. In this study, we used multiple methodologies to conduct a feasibility study for the possibilities of introducing the concept in a developing country, Ghana. An intensive literature review was performed using the Grounded Theory and the Critical Success Factors (CSFs) method to identify the key factors for the introduction of the synchromodal concept. Questionnaires were administered to the primary stakeholders in the maritime-hinterland transportation sector to solicit their views about the factors necessary for the implementation. We next carried out SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to catalogue the strengths and

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PUBLIC INTEREST STATEMENT

Supply chain is growing and increasing globally, and as a result, products travel long distances in recent times than ever before from their origins to reach final destinations (consumers). This has brought about the consumption of larger amount of fuel, resulting in more greenhouse gas (GHG) emissions, and increasing levels of local air pollution. It has been observed that road freight is a major contributor to carbon emissions into the environment. Thus, finding a sustainable system for maritime-hinterland freight transportation has become a concern to all. In this work, we carried out a feasibility study for the introduction of the concept of synchromodal freight transportation system in a developing country, Ghana. Multiple methodologies were used to solicit the knowledge of stakeholders in the freight transportation business about the introduction of the concept. This paper motivates, assists and inspires all researchers interested in sustainable freight transportation system through integrated transport modes.

weakness of the country in introducing the concept. The multiple regression analysis method was used to analyse the experience of stakeholders in the freight transportation business and their knowledge about the synchromodal freight transportation system. The results of the study show that it is possible to introduce the concept in the country. However, there is the need to improve the current transportation and ports infrastructure of the country considerably for successful synchromodal system adaptation. There is also the need for stakeholders education on the concept.

Subjects: Environmental Studies & Management; Engineering & Technology; Development Studies, Environment, Social Work, Urban Studies; Economics, Finance, Business & Industry; Geography

Keywords: freight transportation; intermodal; synchromodal; integrated network; success factors; sustainability

1. Introduction

The quest for achieving sustainability in the transportation sector has been high in recent times. The challenge of shifting from unimodal transportation to more sustainable modes is still confronting many industries and nations. Before the development of the synchromodal freight transportation concept, the unimodal freight transport, multimodal freight transport, intermodal freight transport, combined freight transport and co-modal cargo have been in operation (Bontekoning & Priemus, 2004; De Borger & De Bruyne, 2011; De Langen & Pallis, 2006).

The various freight transportation systems differ from one another in many ways. Some of the differences may be due to the additional key features, the complexity, the organisational systems and legal relations existing among the freight transport stakeholders. The unimodal freight transportation system deals basically with one transport mode, and this more often than not refers to the road transportation system. The multimodal transport system is the system whereby goods are transported by at least two transport modes. The intermodal freight transport system is a unique type of a multimodal system in which goods are transported in one and the same loading unit by successively two or more transport modes without handling the goods themselves during the time of changing modes.

The combined freight transport system, on the other hand, is an intermodal transportation of goods with special emphases on the usage of trucks at the initial and/or final leg of the movement and endeavouring to reduce the transportation distance as much as possible. Co-modal freight transport system, however, is said to be the efficient and effective use of different transport modes on their own and in combination in order to achieve an optimal and sustainable use of transport resources (Behdani, Fan, Wiegmans, & Zuidwijk, 2014; Crainic & Laporte, 1997; De Borger & De Bruyne, 2011). The synchromodal freight transportation system provides additional features to the intermodal and co-modal freight transport system. This function is the area of real-time switching among the various available transport modes in a flexible manner which is obtained through according to the real-time transport information (Behdani et al., 2014). Undeniably, the concept of synchromodal freight transportation system is very new, and its benefits and advantages are yet to be fully exploited through the successful implementation and management of the concept.

Since its introduction and pilot study in the Netherlands in 2010, the synchromodal freight transportation concept has been studied mainly in the country of its origin, and among the European Countries. Plans have been far advanced in these countries especially where the concept has already been implemented and is progressing steadily. In developing countries such as Ghana, the concept is yet to be well known.

According to statistics, more than 90% of international trade is carried out by maritime transportation through container shipment (United Nations Conference on Trade and Development [UNCTAD], 2008). The increase in global commerce is facilitated through higher containership utilisation. Similarly, the container ships accessibility to maritime ports has enhanced operations of supply chain and its related activities. Research conducted by the UNCTAD indicates that, during the last four decades, the total of seaborne trade has increased more than four times to an estimated amount of 8.17 billion tonnes in 2008 (UNCTAD, 2008).

Ghana's maritime trade has seen significant development over the years (Ghana Ports and Harbour Authority [GPHA], 2007). Ghana has two major maritime ports namely, the Tema Port and the Takoradi Port. These ports are regulated by the GPHA. The shipping industry in Ghana with major entities such as the ship-owners Agents Association of Ghana (SOAG) and the Ghana Institute of Freight Forwarders (GIFF) has contributed immensely to the economic and trade development in Ghana. The Ghana Shippers' Council is formed with the sole aim of protecting and promoting the interest of shippers in Ghana. The Council ensures conducive and transparent environment to maintain business efficiently at the ports (GPHA, 2005, 2007).

The throughput of Ghana's cargo has seen a great increase from 954,967 million metric tonnes in 2008 to 12,145,496 million metric tonnes in 2015 (GPHA, 2016b). This drastic growth in cargo throughput is attributed to the country's population increase. The phenomenon has significantly impacted the consumption rate of both local and exotic goods. Coupled with this, the remarkable use of Ghana's maritime ports by the neighbouring landlocked countries-Burkina Faso, Mali, and Niger—has played a major role in the cargo growth (GPHA, 2016a, 2016b). The details of the port performance of the two major ports of Ghana can be seen in Appendix A of this work.

According to Kovacs, Spens, and Roso (2008), the increase in population and a greater economic activity has a direct bearing on maritime container freight transport. This situation consequently results in land surface freight transport growth. The phenomenal increment is, however, affecting the operations of ports and ports business in some ways. On the one hand, the situation is creating lack of space at the ports areas for smooth and efficient operations. On the other hand, the condition is increasing road congestion due to more usage of trucks which is culminating in increased lead-time. These unfavourable conditions are currently prevailing at the maritime ports of Ghana (GPHA, 2005).

To ensure healthy competition with neighbouring ports of the country, there is the need for proactive measures to transport cargo from the maritime ports to the hinterlands and the landlocked neighbouring countries. As postulated by Caesar, Riese, and Seitz (2007), the means whereby people shaped the landscape through time demands imperativeness for business and governments concerns regarding sustainability of food, water, transport, energy, etc.

The construction of dry ports is currently underway in Kumasi through joint efforts of the GPHA, the Ghana Ministry of Transport (MoT) and private development partners (GPHA, 2016b; MoT, 2016). When finished, the inland port or dry port connected with modern railway links all over the country will boost economic activities and help decongest the roads thereby reducing environmental pollutions. The major seaports of the country will also see decongestion as the result of the inland port and cargo throughput will be boosted remarkably. The dry port which is under construction is designated upon completion to serve as a transit for containers being transported to the landlocked neighbouring countries and also operate as a depot, and storage area for container. It is also to provide consolidation services, container maintenance, customs clearance and container monitoring services (MoT, 2016).

According to the Ministry of Transport in Ghana, all old railways are to be rehabilitated within coming few years. Also, there are plans for nation-wide expansion of railway networks. The rehabilitation work has already begun at the Takoradi Ports (GPHA, 2016a).

It is in this regard that the researchers consider Ghana to be a worthwhile country for the feasibility study for the introduction of the concept. The rest of the work is structured in this way; Section 1.1 presents the statement of the problem, and the research methodology is discussed in Section 1.2, Literature review is reported in Section 2; results and discussion are provided in Section 3, and Section 4 contains the conclusions and recommendations for further research.

1.1. Statement of problem

With the ever growing nature of supply chain comes many risks and uncertainties (Seuring, Sarkis, Müller, & Rao, 2008). These risks and uncertainties are felt from the production stage to the end consumer stage. Issues such as quality, customer requirements, flexibility, efficiency, lead-time and cost reduction continue to militate against smooth operation of the supply chain (Fera, Fruggiero, Lambiase, Macchiaroli, & Miranda, 2017; Seuring & Müller, 2008). Variations in consumer demand and its effect of system fluctuation is a burden to all industries. Global distribution network faces challenges of flexibility in delivery to reduce lead time and cost. These issues have induced the global freight transportation system with unsustainable effects (Seuring & Müller, 2008).

The unsustainable nature of the current global freight transportation system has become a challenge to all governments and stakeholders globally. Trade globalisation and the recent industrialisation and technological advancements have led to high demand for freight transportation. Maritime-hinterland transportation of goods has become a burden and an environmental challenge as a result of over utilisation of road transportation as a unimodal system to the detriment of the environment. An attempt in finding lasting solutions to the menace has culminated in the development of the synchromodal freight transportation concept. The concept is developed and piloted in the Netherlands. No developing country has commenced preparations towards the introduction of the new freight transportation system yet. Presently, little is known about the concept in general. However, the idea is capturing the attention of many researchers in recent times (Kannegiesser & Günther, 2014).

In this study, we contribute to the research on the topic by carrying out a feasibility study for the introduction of the synchromodal freight transportation system in a developing country, Ghana. The country is chosen for the survey for several reasons. Firstly, the country is located near the sea with two major maritime ports which are vital in West Africa in particular, and in the whole Africa in general. The ports in Ghana are faced with growing traffic congestions in the port area. The congestion is partly due to the lack of traffic flow, insufficient gate capacity, quality of roads and poor hinterland connections. The lack of effective hinterland connections creates traffic stagnation which is adversely affecting port operational costs, turnaround time of calling vessels and the terminal productivity. Secondly, the seaport serves many landlocked West Africa countries in the transportation of their container freight. Thirdly, there is growing volume of cargo container transport the country, and lastly, the political and economic stability of country and the government's willingness in developing and improving the transportation and ports infrastructures in the country.

1.2. Research methodology

To attain the goals of this research, a five-step methodological approach was designed. First, a critical literature review was conducted using the grounded theory. The grounded theory was used because the subject under study is new and literature available on the topic is scanty. Secondly, a questionnaire was developed based on the information from the literature review. The questionnaire was used to solicit information from stakeholders on the subject of synchromodal freight transportation system. The questions were developed and administered after holding a workshop with the stakeholders. Thirdly, Critical Success Factors (CSFs) approach was used based on the one developed earlier by Pfoser, Treiblmaier, and Schauer (2016) on the topic of synchromodal freight transportation system. We next use the SWOT Analysis method to determine the strengths and weaknesses of the case country for the introduction of the synchromodal system. Standard Multiple Regression Analysis was further carried out on the experience of stakeholders with the parties in the freight transportation business. This same analysis was used to determine the respondents' knowledge about the new freight transportation concept. The model for the research methodology is presented in Figure 1.

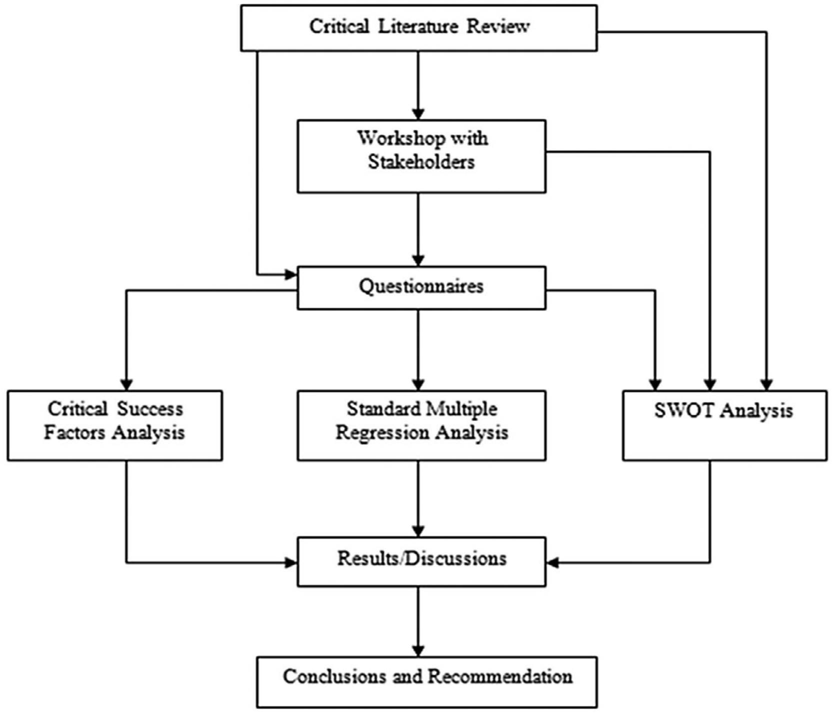


Figure 1. Research methodology model.

2. Literature review

Supply chain is growing and increasing globally, and as a result, products travel long distances in recent times than ever before from their origin to reach final destination (consumers) (Halldórsson, Kovács, Sanchez-Rodrigues, Potter, & Naim, 2010; Naim, Potter, Mason, & Bateman, 2006). With the ever growing nature of modern supply chain comes many challenges and uncertainties. Supply chain uncertainties impact the delivery of greater customer value. Manufacturing companies and industries in the chain deal with supply chain variabilities through the provision of information and communication technology (ICT) systems which are robust in nature. The variations are also addressed by keeping enough inventory. Thus, supply chain uncertainty results in higher total cost (Bask, 2001; Halldórsson et al., 2010; Naim et al., 2006).

The conventional way of uncertainty management in the supply chain is through manufacturing operations. The causes and consequences of supply chain uncertainties have not been viewed from the perspectives of freight transport activities in the past (Bask, 2001; Halldórsson et al., 2010). However, in recent times, it has been realised that transportation forms a vital part of the supply chain and the transport activities widely impacts the supply chain. As a result, meeting the requirements of many customers in the supply chain calls for flexibility in transportation services in the logistics chain. The involvement of shippers, carriers and customers now form an essential part of the logistics and supply chain management (Bhattacharya, Kumar, Tiwari, & Talluri, 2014). Satisfying customers is significantly affected by uncertain events of transportation activities. There is, therefore, the need to improve the effectiveness and efficiency in the management and operations of freight transportation system to minimise the supply chain uncertainties (Bask, 2001; Halldórsson et al., 2010; Naim et al., 2006).

In dealing with transport uncertainties in the logistics and supply chain, transportation systems have been developed and continually optimised (Halldórsson et al., 2010; Naim et al., 2006). The introduction of the intermodal transport network is thought to be a solution to the challenges such as high cost, inflexible delivery times, etc. which make the freight transportation system less sustainable (Bhattacharya et al., 2014). In an attempt to improve the intermodal system, the concept of synchromodal freight transportation system is developed.

The concept of synchromodal freight transportation system is built on three important concepts which are worth discussing. These concepts are the extended gates concept, the pull-to-push system, and the mode-free booking concept. The extended gate system is the one in which an intermodal terminal which is directly linked to the seaport terminals using high-capacity transport. In this situation, customers have the option of leaving or picking up their containers as if they are directly dealing with the seaport and it is possible for the seaport terminal operator to control the container flows to or from the inland terminal. In the Pull-to-Push strategy of container freight transportation, containers are directly transported with barges or by trains from the seaports to inland terminals which are located in the hinterlands. This system avoids the situation whereby containers are left at the seaport waiting for final collection by their respective customers.

The push system is more pro-active in nature, and this prevents undue delay of containers at the seaports. The practice helps prevent the use of trucks which causes high transportation costs and increase in environmental pollution and road congestion. Mode-free booking is an essential aspect of the synchromodal freight transportation concept. The mode-free concept enables shippers to sign contracts for transporting their containers, and the contract is about price, time of container delivery, service quality level and other necessary requirements. The modal booking is left to the transport operators to decide, with the freedom of switching between and among modes as when necessary, using real-time information (Behdani et al., 2014; Van Riessen, Negenborn, & Dekker, 2015b).

The synchromodal freight transportation system is a step ahead of the intermodal and the co-modal freight transport systems. This is achieved through the employment of the mode-free booking strategy which permits flexibility in the selection and switching among several available modes in a timely manner. The synchromodal system allows modifications to be made to the transportation plans based on real-time transport information (Behdani et al., 2014; Riessen, Negenborn, Dekker, & Lodewijks, 2015).

Real-time data collection, integration and its timely utilisation is a pre-requisite in attaining flexibility in the mode-free booking through dynamic changing of modes in the integrated transport network. Designing transport service prices and delivery requirements such as due time, reliability, etc. is also an important aspect of the synchromodal freight transport service. Collaboration and coordination are other essential factors for the success of the synchromodal business. This is because multiple stakeholders are involved in the synchromodal system. Mental shift in the synchromodal freight transportation planning cannot be over emphasised. A change from the culture of mode-base or modal booking to mode-free booking is a requirement for the implementation of the synchromodal freight transportation concept (Behdani et al., 2014; Riessen et al., 2015).

The European Gateway Services is a typical example of synchromodal system. This system is organised by the European Container Terminal which acts as the terminal operator for the transportation of freight containers from the Port of Rotterdam to its hinterlands. A pilot synchromodal project conducted on the Rotterdam-Moerdijk-Tilburg corridor in 2011 yielded a positive result regarding modal split and cost savings. The pilot study proves that the synchromodal system is capable of introducing sustainability into the freight transportation system with much efficiency, effectiveness, flexibility and other potential benefits (Behdani et al., 2014; Lucassen & Dogger, 2012b; Riessen et al., 2015).

2.1. Stakeholders in the maritime-hinterland transportation business

There are several interested parties in the maritime-hinterland transportation business. Each of these stakeholders has their opinions about the new concept of synchromodal freight transportation. They also have varied interests in the transport business which must be met in one way or the other. This calls for collaboration and cooperation among the stakeholders. The various interested parties and their interests are briefly discussed in this section.

2.1.1. Port authorities

Port authorities have general oversight over the ports. In most countries, the ports are owned by the government, as in the case of Ghana ports. In some other countries, the ports are own partly by the government and partly by private entities. The port authorities have control over the port land area and the surroundings of the sea where the port is located. They also have authority over the deep sea terminal and formulate policies for adherence by the terminal operators. The port authorities see to the development of the ports. They develop information and communication systems and partake in all planning processes and new logistics system implementation.

Port authorities are facilitators in the logistics and supply chain; however, the organisation and transportation of goods are not the responsibilities of port authorities. The general overall efficiency of the port and the growth of trade is sole interest of port authorities (Dooms, van der Lugt, & de Langen, 2013; Van den Berg, De Langen, & Rúa Costa, 2012).

2.1.2. Deep sea terminal operators

Deep sea terminal operators have commercial relationship with port authorities and ocean carriers. They interact with many international stakeholders in the transportation business, and their activities affect these stakeholders. These activities include loading and unloading ocean-going vessels operating at the terminal. Ocean carriers normally pay deep sea terminal operators for their work. Sometimes, deep sea terminal operators provide additional services such as provision of storage facilities for empty containers. However, this is not their core business. Deep sea terminal operators cooperate with cargo owners, freight forwarders, and inland transportation service providers or inland terminal operators in providing hinterland transportation. They have commercial relationship with only ocean carriers (Franc & Van der Horst, 2010; Heejung, 2015).

2.1.3. Ocean carriers

Ocean carriers own or hire ocean vessels which provide port-to-port international cargo transportation through freight containers. The port-to-port ocean transportation services of ocean carriers are procured by cargo owners and freight forwarders. In recent times, ocean carriers are entering into the service of hinterland transportation (Sislian, Jaegler, & Cariou, 2016).

2.1.4. Freight forwarders

Freight forwarders provide logistics services on behalf of cargo owners; however, they do not own vessels, trains, terminals, or trucks. They procure transport services from transport providers. Freight forwarders work closely with transportation service providers and cargo owners. Their responsibilities include designing and integration of activities about deep sea and hinterland in the supply chain of cargo owners. Freight forwarders also provide logistics services such as consultancy, freight consolidation, deconsolidation, etc. their customers (Bae & Ha, 2014; Tongzon, 2009).

2.1.5. Inland transportation service providers

Inland transportation service providers offer inland transportation services. Trucking companies, rail and barge companies represent inland transportation providers. They are responsible for inland container transportation from maritime ports to hinterlands and hinterland terminals. They have direct relationship with cargo owners, deep sea terminal operators and other transportation service providers. Sometimes, inland transportation providers engage in warehousing activities. Ocean carriers, freight forwarders, deep sea and inland terminal operators procure services from inland transportation providers (Rohács & Simongati, 2007; Tzannatos, Tselentis, & Corres, 2016).

2.1.6. Inland terminal/operators
The activities of inland terminals located in hinterlands are similar to that of deep sea terminals. Inland terminals could be barge or rail terminal which can be accessed by trucks. Inland terminals have the potentials of handling containers and provide means of consolidation and deconsolidation. This enables and enhances modal shift between inland transportation modes. Inland terminal operators carry out transportation networks in collaboration with Inland model carriers (i.e. barge, rail and truck) (Hayut, 1980; Rodrigue & Notteboom, 2009; Van den Berg & De Langen, 2015).

2.1.7. Cargo owners
The demand for international transportation is based on the fact that cargo owners need means for the transportation of their goods. Cargo owners are the drivers of the demand for efficient and effective global transportation. Several names are attributed to cargo owners some of which are traders, consumers, shippers, receivers, importers, exporters, etc. Cargo owners procure almost all of their transportation services from external transportation service providers. However, they may design their own door-to-door services. The transportation decisions of cargo owners are based on service quality, cost, flexibility, reliability, transit time, service frequency, sustainability, service availability, etc. (Brooks & Schellinck, 2015; Cariou & Wolff, 2011).

2.2. The advantages and challenges of synchromodality
The advantages and challenges confronting synchromodality concept are discussed below.

2.2.1. Advantages of synchromodality
The advantages that could be derived from synchromodal system can never be over emphasised. The following are some major benefits that can be obtained by implementing this concept.

(i) Environmental sustainability (green logistics): the emphasis is on modal shift from trucks to rail and barges.

(ii) High economy of scales: it has the overall cost benefits as the emphasis on lowering cost by volume for mutual gain.

(iii) Information network symmetry: this system encourages seamless sharing of information for mutual gains among parties involved.

(iv) Better link between hinterland and maritime ports: the inland and seaport are joined in a more sustainable manner thereby allowing easy flow of transportation and other logistics within the supply chain.

(v) High level of efficiency: the system is more reliable, robust and takes lower cost considerations.

(vi) High-level effectiveness: the system is more flexible and high responsive to customers demand and satisfaction.

(vii) More collaborative and consolidative system: it combines most modes of transport on a common platform and in parallel.

(viii) Pull & Push system: it caters for demand and supply fluctuations and uncertainties as it serves the interests of all parties.

(ix) Better utilisation of transport and infrastructures: it enhances greater capacity utilisation of available facilities at the ports like warehouses, etc.

(x) Freedom of mode choice: the system allows logistics service providers to freely choose alternative modes for higher level of service benefits.

(xi) Better modal split: it offers a more modal split benefits as compared with other strategies.

Synchromodality concept has benefits for all the actors/stakeholders within the synchromodal business. The benefits to shippers, services providers and authorities/citizens are summarised in Table 1.

Table 1. Benefits of synchromodality to the various actors/stakeholders

Benefits for shippers	Benefits for service providers	Benefits for authorities/citizens
• Flexible: barge/rail/shortsea when possible, road when urgent • Lower cost/improved service if in line with requirements client • Dynamic planning makes mode switching possible • Step forward in sustainability (CO_2 target)	• Opportunity: increase volumes for barge/rail/shortsea transport • Improved quality of service: attracting clients and turnover • Deepsea terminal: Barge/rail volumes easier to handle than road (max. 3 TEU/truck) • Step forward in sustainability (CO_2 target)	• Improved use of capacity existing infrastructure • Less road transport (congestion) • Improved competitive position and vitality of companies (job security in long term) • Step forward in sustainability (CO_2 target)

2.2.2. Challenges confronting the synchromodality concept
Every new concept comes with some difficulties and challenges at the initial stage, and the synchromodality concept is no exception. Few challenges confronting the synchromodality concept are discussed below (Shang, Lu, & Li, 2010).

2.2.2.1. Challenges for business:

(i) Network design organisation: The key issues here have to do with bundling volumes, adjusting business models and the sharing of benefits and costs.

(ii) Control tower organisation: this demands intensive cooperation, widely available provision of information, developing decision models and optimal communication.

(iii) Bookings and planning: there is more to be done in encouraging modal-booking and cooperation in planning by all parties in the synchromodal business. For the planning to be effective, it must be done jointly by all the parties involved.

(iv) Creation of flexibility: the realisation of flexible processes, the solution of administrative bottlenecks and eliminating inequalities in insurance terms between modalities remains an issue to be dealt with within the synchromodal concept.

2.2.2.2. Challenges to public:

(i) Modal split influence: there is the need to set up the right preconditions and incentives for the choice of the required hinterland modes by all parties.

(ii) Integrated planning: governments need to provide the right infrastructure for optimal information exchange and participate actively in the synchromodal business. There is also the need for governments to facilitate co-education in the integral (synchromodal) plans.

(iii) Realisation of a core network: another major challenge confronting the synchromodality concept is the realisation of a core network. This could be achieved by stimulating the development of a trimodal network with a selective choice of location for inland terminals. This must link municipal, county and states jointly. Also, there is the need for the creation of legal synchromodal connections with neighbouring countries.

(iv) Synchromodal Frame: ensuring equal legal approach to road, rail, inland waterway, air and maritime transport, on the borders, to arrive at synchromodal transport law is yet another challenge confronting the synchromodal system.

The above-mentioned challenges do not pose any threat to the potentials of the synchromodal concepts but are rather seen as necessary steps to be taken to ensure the implementation and the fulfilment of the concept. The potential benefits to be derived from the concept far outweigh the challenges enumerated.

2.3. Synchromodal transport pilot study

A synchromodal transport pilot study was conducted by a group of researchers in the Netherlands from December 2011 to May 2012 involving some parties on the transport corridor Rotterdam-Moerdijk-Tilburg. It is worth stating that the concept of synchromodality originates from the Netherlands (Lucassen & Dogger, 2012a). The pilot project looked at how logistics service providers could arrange a synchromodal transport, without negative effects on the reliability and efficiency of the transportation system. Important elements here were the design of transport network, the necessary changes in collaboration and business models and the central coordination of the transport system.

There was a favourable outcome from the modal split project. The modal split in the transport corridor Rotterdam-Moerdijk-Tilburg shows that synchromodal use of a tri-modal network where shippers of a container books transport service and allows the service providers to select the appropriate modality had positive effects. Combined with optimal cooperation between all parties a good result was obtained. There was a modal shift from road to rail and water. Apart from a more favourable modal split, there was also a better utilisation of infrastructure.

The pilot project of synchromodality shows a substantial reduction of CO_2 emissions. The transport on the Rotterdam-Moerdijk-Tilburg realized modal split which led to a significant percentage reduction in CO_2 emissions. The study clearly shows that synchromodality has the potentials of positive effects on transport in the logistics chain.

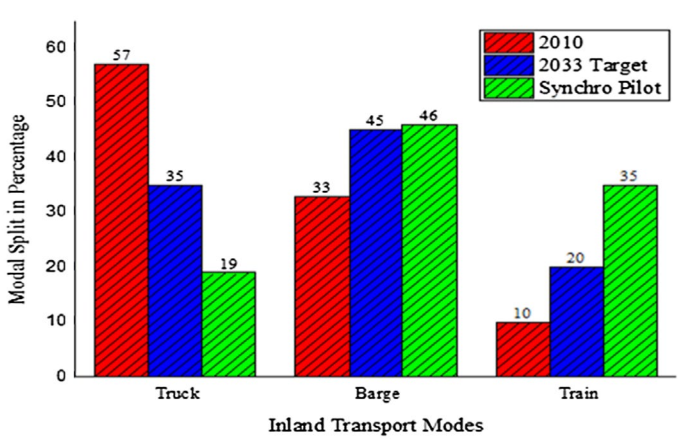
The performance of the synchromodality pilot project is indicated in Figure 2. It represents the modal split for truck, barge and rail for the port of Rotterdam in the year 2010. It is quite interesting to note that the modal split targets for 2033 are even lower as compared with the modal split results obtained for the network in the pilot project.

The results, therefore, shows that the emission of CO_2 into the atmosphere causing greenhouse gases will reduce proportionately as there is a modal shift from trucks to rails and barges hence supporting synchromodality as a means of ensuring sustainability of transportation in logistics and supply chain management (Behdani et al., 2014; Lucassen & Dogger, 2012a, 2012b).

2.4. Success factors for the introduction of synchromodality

The CSFs method was proposed and used by Daniel (1961). Other researchers who used the CSFs concept in their research were Rockart (1978), Bullen and Rockart (1981), and Caralli, Stevens, Willke, and Wilson (2004). Pfoser et al. (2016) recently used the CSFs method on the topic of synchromodality.

Figure 2. Modal split for truck, barge and rail for the Rotterdam port in 2010 (Lucassen & Dogger, 2012a).



Bullen andRockart (1981) defined CSFs as "the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organisation. CSFs are the few key areas where 'things must go right' for the business to flourish and for the manager's goals to be attained". According to Caralli et al. (2004), CSFs are "key areas of performance that are essential for the organisation to accomplish its missions". Similarly, Pfoser et al. (2016) consider CSFs as the "critical factors or activities which are required to ensure the success of a business or a project". They opine that identifying CSFs is very essential since they help in directing one's efforts and abilities to developing the capabilities that are important in attaining the necessary success factors. The work of Caralli et al. (2004) suggests that the first and major step in the CSFs analysis is the critical identification and gathering of important data.

2.4.1. CSFs for synchromodality

This section discusses the CSFs for synchromodality as identified in literature review. These CSFs are catalogued in Tables 2 and 3.

2.4.1.1. Network, collaboration and trust. Network generation based on mutual trust and collaboration has been identified as a major success factor for the implementation and operation of the synchromodal transport business. Trust and collaboration are very necessary because many companies and business entities feel reluctant in cooperating with each other for fear of market competition. To achieve win-win game in the synchromodal business, coordination among the many actors and players is very essential. This could be enhanced through fair gain and risk sharing.

2.4.1.2. Sophisticated planning. Sophisticated and dynamic planning and simulation of transport routes and its corresponding patterns have been pointed out as the next important pre-requisite for the creation of a workable and robust synchromodal freight transport network. Critical evaluation and examination of customer preferences, busy routes and available transport resources and modes are very vital. Ensuring this will call for good forecasts and simulations for the purpose of transport performance optimisation. The utilisation of available transport resources and container capacity for the synchromodal system will demand a robust and resilient supply chain framework and a well-organised planning.

2.4.1.3. ICT/ITS technologies. ICT/ITS technologies and their application in the synchromodal transport system cannot be over emphasised. The employment of ICT and ITS technologies will assist in offering a high quality and standardised data. They will also help in sharing and exchange of relevant transportation and other related data in the synchromodal process. The numerous players and actors involved in the synchromodal business imply that there must be fast and accurate means of sharing and exchange of real-time data. Real-time information is also needed for the efficient and effective utilisation of transport resources and also for the enablement of switching between transport modes in a dynamic way. The use of ICT will enhance transport planning optimisation and automation of synchromodal processes.

2.4.1.4. Physical infrastructure. Availability of physical infrastructure is very vital in the implementation of the synchromodal transport system. There is the need for intelligent physical infrastructures such as smart hubs which are connected with smart corridors. Intelligent physical infrastructures like smart ports and smart terminals will ensure seamless transportation process in the synchromodal system. This will yield the benefits of efficient and effective infrastructure utilisation.

2.4.1.5. Legal and political framework. The success and progress of the implementation of the synchromodal system will greatly depend on the legal and political environment. The effective and efficient functioning of the synchromodal business will be promoted by putting a firm legal and political framework in place. Legal issues such as risk and gain sharing will arise among the many parties in the synchromodal business. Other issues that are likely to crop up during the operation of the system are who is to take responsibility for liabilities, (e.g. delays, damages, losses, etc.) and who

Table 2. Synchromodality critical success factors as presented in literature

Reference	Network/ cooperation/ trust	Sophisticated planning	ICT/ITS technologies	Physical infrastructure	Legal/ political framework	Awareness/ mental shift	Pricing/ cost/ service
Ambra, Caris, and Macharis (2016)	x	x	x				x
A. E. P. Rivera and M. R. Mes (2016)	x	x	x	x			x
A. P. Rivera and M. Mes (2016)	x	x	x				x
Bol Raap (2016)	x	x	x	x			
Ponweiser et al. (2016)	x	x	x	x	x	x	x
Pfoser et al. (2016)	x	x	x	x	x	x	x
Mes and Iacob (2016)	x		x				x
Raap, Iacob, van Sinderen, and Piest (2016)			x	x			
Savy (2016)	x	x	x	x	x		
Zhang and Pei (2016a)		x	x				x
Zhang and Pel (2016b)		x	x	x			x
Kapetanis, Psaraftis, and Spyrou (2016)		x	x	x			x
Tsertou, Amditis, Latsa, Kanellopoulos, and Kotras (2016)		x	x				x
Vinke (2016)	x	x	x	x			x
Holfeld and Simroth (2016)	x	x	x	x	x	x	x
Li, Negenborn, and De Schutter (2016)	x	x	x	x	x	x	x
Pomponi, Fratocchi, and Rossi Tafuri (2015)	x						x
Singh and van Sinderen (2015)		x	x	x			
Putz, Haider, Haller, and Schauer (2015)	x	x	x	x	x	x	x
Riessen et al. (2015)	x	x	x	x	x	x	x
Riessen et al. (2015)		x	x				
Tavasszy, Behdani, and Konings (2015)	x	x	x	x	x	x	x
Xu, Cao, Jia, and Zang (2015)		x					
Buiel et al. (2015)	x	x	x	x	x	x	x
Van Riessen, Negenborn, and Dekker (2015a)		x	x	x			x
Murillo (2016)		x					x
Behdani et al. (2014)	x	x	x	x	x	x	x
Singh (2014)		x	x	x			
Hofman (2014)			x				
Oonk (2014)	x	x	x	x	x		
Lucassen and Dogger (2012b)	x	x		x	x	x	x
Ham (2012)	x	x	x	x	x	x	x
Pleszko (2012)	x	x	x	x	x	x	
Rossi (2012)	x	x	x	x	x	x	x
Van der Burg (2012)	x	x	x	x	x	x	x
Fransoo (2011)	x	x	x	x	x	x	x
Verweij (2011)	x	x			x	x	
Total = 37	25	33	32	26	18	16	26

Table 3. Critical success factors of synchromodality (Pfoser et al., 2016)

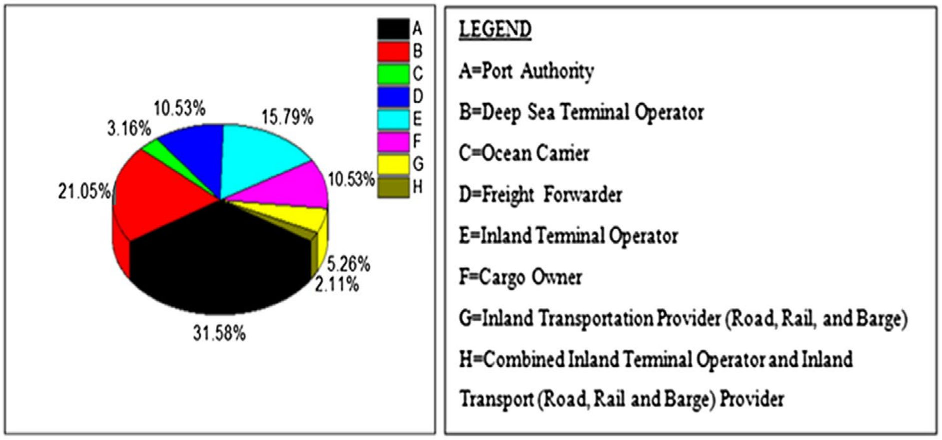
Transport-related	External conditions	Customer-related
Network/cooperation/trust	Physical infrastructure	Awareness/mental shift
• Organisational issues: align interest of multiple stakeholders, organise relations, gain and risk sharing • Need for other players: you are reliant on other players in the supply chain • Administrative processes to allow to cooperate between modes • Other ways of negotiation • Trust of shippers • How much competition is there in the synchromodal market? How much cooperation is needed to be successful?	• Network of modes and routes • Reliable connections, at least daily train connections • Hardware (i.e. terminals, hubs, streets, etc.)	• Cultural view and mental shift • Orgware: mind shift from shippers and logistics service providers. Shippers have to understand that it takes a lot of freedom from the system when shippers decide mode. Mental shift to release control • Willingness of shippers to accept that LSP or intermodal operator can choose mode and performs on his own
Sophisticated planning	Legal/political framework	Service cost and pricing
• Integrated planning • Standardisation of the transport itself • Software side of the information system, good information • Ability to plan and use modes of transport you need to come up with a system which can use resources efficiently	• Role of public sector and government investments required • Regulations: insurance terms are different, role of public sector development of infrastructure • Orgware: Governance • Legal conditions (different modes of transport but only one bill of loading, dangerous goods, etc.)	• Price combined with quality is important for customers • Not just minimum cost but balance between cost and efficiency • Cost aspects • Service level, reliability • Different price mechanisms to make it work • You need to know what customers want • Pricing questions: if you have not specified the modality, you are in the situation that profit depends on the execution, agree in advance but may renegotiate the price
ICT/ITS technologies		
• Technology enabler • Tools (i.e. ICT/ITS technologies) • Hardware: technology (sensors, ICT, ITS, different load units) • Communication system (ITS, communication, information technologies		

is to pay for resources and infrastructure. Areas such as information sharing need to be supported by rigorous legal frameworks.

2.4.1.6. Awareness and mental shift. Awareness and mental shift is another critical success factor for the synchromodal concept implementation. It is required of all players and customers to make a mental shift from the traditional modal-booking to mode-free booking. Without mode-free booking, there would not be any synchromodal business. The awareness for this mental shift has to be created by the synchromodal logistics service providers through systematic and strategic education.

2.4.1.7. Service cost and pricing. The synchromodal freight transport business has service cost and pricing as an important aspect. The patronage of the synchromodal transport services by customers will largely be influenced by these factors. Flexibility, reliability and timeliness are key influential factors for the success of the synchromodal system. Prices must be reasonably moderate, and there must be waiting for penalties to compel service providers and customers to be on time in supply and delivery of transport services. Advanced pricing and timing would be greatly affected by dynamic switching between modes hence carefulness is needed in order not to incur extra costs.

Figure 3. Categories of stakeholders involved in the survey.



3. Results and discussions

The respondents of the questionnaires comprise Port management authorities, transport management authorities, shippers, transport service providers, clearing agents, legal experts in the transport business. In all, about 100 questionnaires were administered out of which 95 were answered and returned.

3.1. CSFs analysis

The seven CSFs were used to prepare questionnaires which were administered to stakeholders in the logistics and transport business in the case study country. The respondents were asked to determine the feasibility of each of the success factors identified and how they will impact the successful implementation of the synchromodal concept in the country.

The degree of feasibility of the CSFs was rated using a scale from 1 (=Very low) to 5 (=Very high). The mean of the responses from the 95 respondents is used to determine the degree of feasibility. The results of the analysis can be seen in the Figure 3.

The lower right corner of the quadrant represents the major critical factors which are very important but are however not very feasible. ICT/ITS technologies are one of the major critical factors which are considered less feasible. Sophisticated planning, physical infrastructures, service cost and pricing, and legal/political frameworks are also considered less feasible, though they are very important. The viable success factors are positioned in the upper right corner of the quadrant. These factors are considered as less problematic according to the study. Awareness/mental shift and network/cooperation/trust fall within this position. The respondents are of the view that some cooperation and collaboration already exist among players in the current fright transport business due to long-cultivated business-culture. They opined that the implementation of the synchromodal concept would help improve the existing trust among the business partners. Experts in the field explained that issues of bundling and freight consolidation are currently under discussion.

The upper left corner of the quadrant represents CSFs that are low in importance but high in feasibility. However, none of the CSFs was found within this section, according to the results of the analysis of the views from the respondents. Similarly, the lower left corner of the quadrant represents the CSFs that are less feasible and less important. Here again, there are no CSFs within this region according to the analysis.

3.2. SWOT analysis

As a further probe into the study of the feasibility of introducing the concept of synchromodal freight transportation in a developing country (Ghana), the researchers performed SWOT Analysis to

Table 4. SWOT analysis for the introduction of synchromodality in Ghana

Strengths	Weaknesses	Opportunities	Threats
(i) Political stability (ii) Developing economy (iii) Major seaports development (iv) Manpower development (v) Gateway to neighbouring landlocked countries (vi) Major ICT development (vii) Good ports administration process	(i) Inadequate ports and transport infrastructure (ii) Inadequate capital (iii) Lack of operational dry port (iv) Lack of ITS systems and infrastructure (v) Insufficient and underdeveloped railway system (vi) Lack of sustainable hinterland connections (vii) Low operational efficiency at ports (viii) Current slow turnaround times at the ports	(i) Ever growing demand for freight containers in home and neighbouring landlocked countries (ii) Current trade globalisation making the country hub of West Africa (iii) Future growth in Public Private Partnerships for maritime and inland port development and freight transportation	(i) Completion from neighbouring coastal countries (ii) Unforeseen future economic decline (iii) Unforeseen political instability. (iv) Change of political government. (v) Security issues

identify the strengths, and weaknesses, among other things, of the country. The summary of the analysis is presented in Table 4.

We endeavoured to find out the parties from which the respondents' companies procure inland transportation services. From the results of the analysis, 15.46% does not organise inland transportation and 11.34% procures from port authorities. The rest of the various responses could be seen in Figure 4. Practically, freight container transportation in and through the country to neighbouring landlocked countries is mainly done by road. The various organisations in the freight transportation business organise the inland transportation in their own way, which is mostly through outsourcing.

The freight transport stakeholders were asked to identify which entities they sell inland transportation to. The results for this could be seen in Figure 5. About 16% sells inland transportation to some of the port authorities who organises transportation of freight containers from the maritime to hinterland and landlocked countries. However, this is not the core business of the port authorities.

The knowledge of the stakeholders about the concept of synchromodal freight transportation was tested after holding a workshop for them on the concept. First, the stakeholders were asked to give an account of their familiarity with the term "Synchromodal freight transportation". The results of the test are presented in Figure 6. About 31% of the stakeholders have heard of the concept before the workshop, but their companies were not practising it. None of the organisations of the stakeholders is currently practising the concept since the concept has not yet been introduced into the country's transportation system (Buiel et al., 2015).

Figure 4. Critical success factors classifications.

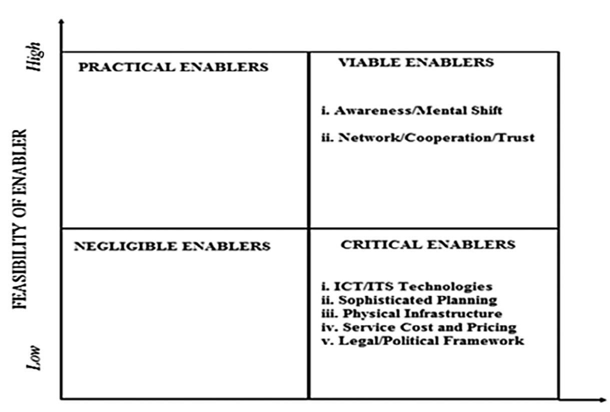


Figure 5. Parties from which the respondents' companies procure inland transportation services.

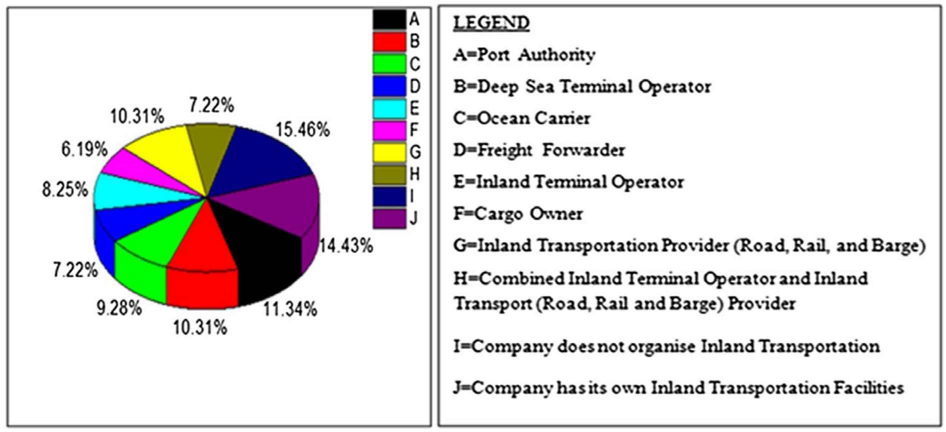
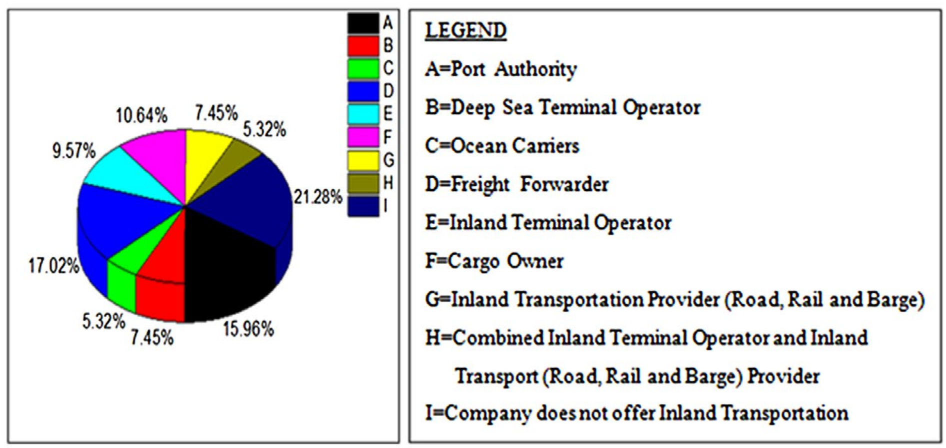
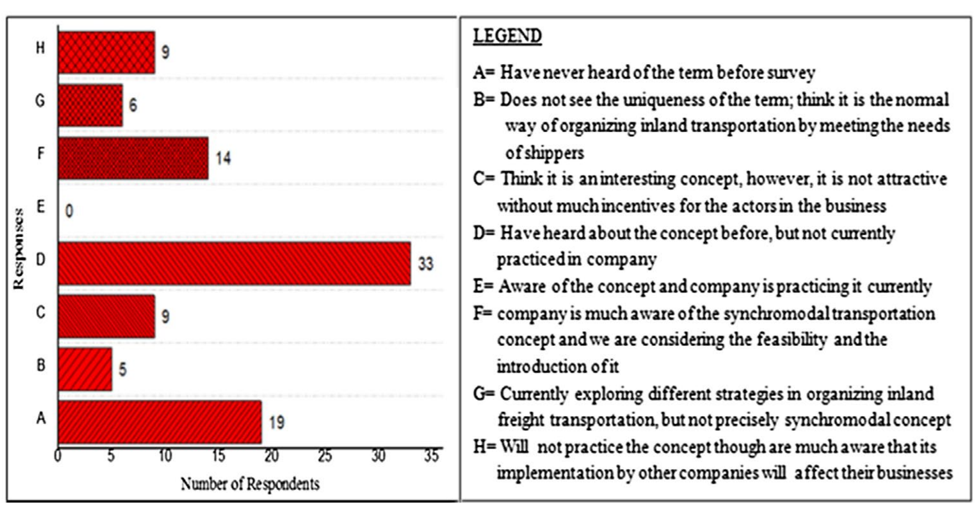


Figure 6. Entities to whom stakeholders sell inland transportation.



Secondly, the stakeholders were presented with some of the vital factors to consider when choosing mode for inland transportation. They were to indicate which of the factors their companies consider or are likely to consider when procuring inland transportation. The results of this survey are presented in Figures 7 and 8. Cost and price emerge to be the major factor mostly considered by the companies. Sustainability (CO_2 emission) issues are least considered by the companies. This is not

Figure 7. Stakeholders familiarity with the term Synchromodal freight transportation.



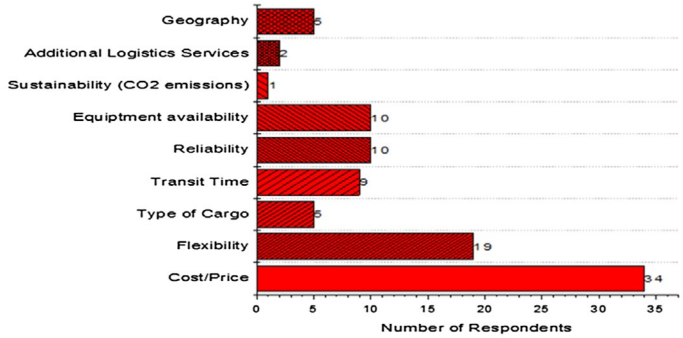


Figure 8. Factors to consider when choosing mode for inland transportation.

suprising because the challenges of emissions and how to integrate its management into the freight transportation sector remains a great force to reckon with. There is therefore the need to educate the stakeholders in the transportation business of the country on the necessity of factoring sustainability issues into their freight transportation operations and management plans (Kontovas & Psaraftis, 2016).

3.3. Stakeholders experience and knowledge about synchromodal transportation concept

The standard multiple regression analysis was run to predict the customer's relationship with various inland transportation stakeholders. The customers' experience was entered in the model as dependent variables with the various stakeholders entered as predicted variables.

In Table 5, the model as a whole could predict 58% of variance in customers experience with the transport stakeholders suggesting average relationship among them. This implies that when the concept is implemented there will be cooperation among the parties involved. Among the stakeholders, four out of eight were significant. Combined inland terminal and transport ($\beta = 0.28$, $p < 0.05$), freight forwarders and ocean carriers ($\beta = 0.20$, $p < 0.05$) were related to higher level of stakeholders relationship. Even though in Ghana, cargo owners are part of the major stakeholders in transportation, the respondents indicated that cargo owners ($\beta = -0.17$, $p < 0.05$) relationship with customers was not encouraging. The results reflect the actual transportation situations in Ghana. However, the findings indicated that the cargo owner's relationship with customers is more critical in achieving successful implementation of the synchromodal concept. Therefore more education in the future should focus on cargo owners to improve their cooperation with the customers (Fransoo, 2011).

Table 5. Regression analysis for predicting customers self-reported experience with the various inland transportation stakeholders ($N = 95$)

	Variables	Mean	SD	β	R^2	Adj. R^2	F
1	Port authority	2.13	0.95	0.09			
2	Deep-sea terminal operators	2.17	0.97	0.13			
3	Ocean carriers	1.45	0.88	0.20*			
4	Freight forwarders	2.44	1.08	0.20*			
5	Inland transportation terminal operators only	2.24	1.10	0.15			
6	Inland transport providers only	2.16	1.18	0.06			
7	Cargo owners	2.54	1.28	−0.17*			
8	Combined inland terminal & transport	2.32	1.13	0.28*	0.58	0.54	14.62**

Notes: β: Standardized regression coefficient; R^2: Variance explained; Adj. R^2: Adjusted R^2; SD: Standard deviation.

*Significance level at $p < 0.05$.

**Significance level at $p < 0.001$.

Table 6. Regression analysis for predicting customers self-reported environmental advantages of synchromodal transportation system (*N* = 95)

	Variables	Mean	SD	β	R^2	Adj. R^2	F
1	Environmental sustainability	3.56	1.23	−0.04			
2	Less road transport	4.01	1.04	0.41***			
3	Step forward in sustainability	4.00	1.10	−0.48***			
4	Better link between ports	3.74	1.14	−0.10			
5	Better utilization of transport and Inf.	4.65	0.98	0.26*			
6	Deep-sea terminal	5.23	0.99	−0.14			
7	Reduced congestion at sea port terminal	4.10	1.20	0.32**			
8	Better model split	3.71	1.20	0.07	0.36	0.29	5.85***

Notes: β: Standardized regression coefficient; R^2: Variance explained; Adj. R^2: Adjusted R^2; SD: Standard deviation.
*Significance level at $p < 0.05$.
**Significance level at $p < 0.01$.
***Significance level at $p < 0.001$.

3.3.1. Advantages

The prediction of stakeholders perceived environmental advantages of synchromodal system are presented in Table 6. Out of the eight items presented, four items had significant beta coefficients with less road transport, and reduced congestion at sea port terminal were the items making the strongest unique positive environmental advantages when synchromodal system is implemented. The result further indicated that better utilisation of transport and infrastructure was indicated to be one of the advantages to be derived from synchromodal system. These results imply that, the stakeholders recognise that, the implementation of the concept will reduce cost and improve environment sustainability. Furthermore, step forward in sustainability made negative contribution, indicating that, the respondents think synchromodality does not promote sustainability. This imply that the stakeholders have not yet understood completely the concept of sustainability and why it should be incorporated into the transportation operation (Buiel et al., 2015). The model as a whole accounted for 36% ($R^2 = 0.36$) observed variance in the advantages of the synchromodal concepts which is relatively low.

In Table 7, out of the eight items presented to access the stakeholders perception on economic and social advantages of the synchromodal transportation, five items had significant beta coefficients with high economic of scales and freedom of mode choice, high level of effectiveness and pulled and push system made a positive prediction of economic benefits of the implementation of synchromodal system (Verweij, 2011).

Table 7. Regression analysis for predicting customers self-reported economic and social advantages of synchromodal transportation system (*N* = 95)

	Variables	Mean	SD	β	R^2	Adj. R^2	F
1	High economy of scales	3.03	1.22	0.24*			
2	High level of efficiency	3.15	1.20	0.12			
3	High level of effectiveness	3.87	1.19	0.20*			
4	More collaborative and consolidative	4.48	1.11	0.04			
5	Pull and push system	2.62	1.29	0.20*			
6	Improve quality of service	4.64	0.89	−0.21*			
7	Improve competitive and company validity	4.80	0.93	0.17			
8	Freedom of mode choice	3.85	1.30	0.22*	0.49	0.45	10.40**

Notes: β: Standardized regression coefficient; R^2: Variance explained; Adj. R^2: Adjusted R^2; SD: Standard deviation.
*Significance level at $p < 0.05$.
**Significance level at $p < 0.001$.

Table 8. Regression analysis for predicting customers self-reported challenges of synchromodal transportation system (N = 95)

	Variables	Mean	SD	β	R^2	Adj. R^2	F
1	Network design organization	2.49	1.30	0.31**			
2	Control tower organization	2.30	1.21	0.37**			
3	Booking and planning	2.03	1.04	0.47***			
4	Creation of flexibility	2.20	1.13	−0.11			
5	Modal split influence	2.78	1.29	−0.16*			
6	Integrated planning	2.70	1.24	0.35***			
7	Realization of score network	1.94	1.05	−0.36**			
8	Synchromodal frame	2.36	1.26	−0.06	0.62	0.58	17.22***

Notes: β: Standardized regression coefficient; R^2: Variance explained; Adj. R^2: Adjusted R^2; SD: Standard deviation.
*Significance level at $p < 0.05$.
**Significance level at $p < 0.01$.
***Significance level at $p < 0.001$.

However, the results further indicated that improving the quality of service made a negative prediction. This means that the stakeholders believed synchromodal concept might not improve the quality of service. The model as a whole accounted for 49% (R^2 = 0.49) observed variance in the advantages of implementing synchromodal concept.

3.3.2. Challenges

The stakeholder's challenges of synchromodal transportation system were further examined (see Table 8). According to the result, the participants indicated that booking and planning ($\beta = 0.47$, $p < 0.001$), control tower organisation ($\beta = 0.37$, $p < 0.001$), integrated planning ($\beta = 0.35$, $p < 0.001$) and network designed organisation ($\beta = 0.31$, $p < 0.01$) were the highest challenges to the introduction of the synchromodal system. However, booking and planning made the strongest unique contribution to prediction of the challenges faced by stakeholders. Moreover, the result shows that the realisation of core network and modal split influence were not much challenge to the concept. In all, the model predicted 63% (R^2 = 0.63) of challenges of the concept. By previous studies, the above challenges are general identified challenges to the synchromodal systems (Behdani et al., 2014; Buiel et al., 2015). Hence, there must be interventions to address these challenges for smooth implementations of the concept.

3.3.3. Disadvantages

In Table 9, the prediction of stakeholders perceived disadvantages of synchromodal system are presented. The model as a whole predicted 56% (R^2 = 0.56) with lack of modal choice by customers ($\beta = 0.30$, $p < 0.01$), making the strongest unique contribution the prediction of disadvantages. The

Table 9. Regression analysis for predicting customers self-reported disadvantages of synchromodal transportation system (N = 95)

	Variables	Mean	SD	β	R^2	Adj. R^2	F
1	Complexity of business process	1.94	1.11	−0.05			
2	Limited differentiation is leading to less sup.	4.32	1.61	0.02			
3	Shipment can stick between two modes	4.46	1.15	0.28*			
4	Higher cost for extra flexibility and rel.	4.67	1.42	0.24*			
5	Lack of modal choice by customers	4.69	1.27	0.30**	0.56	0.53	22.09***

Notes: β: Standardized regression coefficient; R^2: Variance explained; Adj. R^2: Adjusted R^2; SD: Standard deviation.
*Significance level at $p < 0.05$.
**Significance level at $p < 0.01$.
***Significance level at $p < 0.001$.

respondent also believes that, with synchromodal system, shipment can stick between two modes and there is possibility of higher cost for extra flexibility and reliability. The above results reflect the identified challenges in synchromodal concept. The stakeholders need to be educated on the advantages which far outweigh the perceived disadvantages of the synchromodal system (Zhang & Pei, 2016a).

4. Conclusions and recommendation

Synchromodality is the new paradigm shift in the freight transportation sector. The concept which originates from the Netherlands has to do with the synchronisation of physical resources, business processes and the parallel use of transportation modes in a mode-free way to offer shippers a more flexible and sustainable means of freight transportation. The concept of synchromodal freight transportation system is originally introduced and piloted in the Netherlands. In the meantime, no other country has introduced the concept yet. It is an undeniable fact that the concept of synchromodality is at its embryonic stage and many studies are underway by students and experts in the field of transportation and logistics in the Netherlands about the full development and implementation of the concept.

Cost efficiency and effectiveness, reliability, are some of the other benefits of the new concept. Synchromodality is a step ahead of intermodal and co-modal transportation systems with the ability of switching between modes with real-time transport information during maritime-hinterland transportation.

In this research, we endeavoured to explore the feasibility of implementing synchromodal freight transportation concept in a developing country (Ghana). From literature review, seven CSFs were identified, and these are Network/cooperation/trust, sophisticated planning, ICT/ITS technologies, Physical infrastructure, legal/political framework, awareness/mental shift and service cost and pricing. Awareness/mental shift and network/cooperation/trust are considered to be viable enablers while the rest of the CSFs are seen as critical enablers.

SWOT analysis performed on the developing country reveals the strengths, weaknesses, the opportunities and threats of the possibilities of introducing the synchromodal concept in the country. It is worth saying that, focusing on the strengths while dealing with the weaknesses will be the best approach since there are equal opportunities which far outweigh the threats.

The standard multiple regression analysis performed on the stakeholders shows that they are much aware of the concept of synchromodal freight transportation system. However, their companies are not practising it yet since the concept has not been introduced in the country yet. Further findings from the study indicate that the cargo owner's relationship with customers is more critical in achieving successful implementation of the synchromodal concept. Therefore more education should focus on cargo owners to improve their cooperation with the customers. Similarly, stakeholders recognise that the introduction of the concept will reduce cost and improve environment sustainability. It was however realised that stakeholders need to be more enlightened on how the synchromodal system will enhance sustainability.

The stakeholders believed the synchromodal concept might not necessarily improve the quality of service. They are also of the opinion that modal-booking and planning are some of the major challenges in the introduction of the concept. However, they purported that the realisation of core network and modal split influence are not much challenges to the concept. Strong revelation gathered from this study as believed by stakeholders is that with synchromodal system, shipment can stick between two modes and there is possibility of higher cost for extra flexibility and reliability. The stakeholders need to be educated on the advantages which outweigh the anticipated disadvantages of the synchromodal system.

Several key observations have been made in this study which has direct implications for the introduction of the concept of synchromodal freight transportation system in many countries. Firstly, the

CSFs identified may have varying weights in different countries and among different stakeholders. In developed countries where there are adequate transportation and technological infrastructures, mental shift/awareness creation, legal/political framework, service cost and pricing, cooperation and trust will be the focus. However, in developing countries, physical infrastructure and technological development will be a great challenge to battle with.

Secondly, it has been observed that the concept will thrive in the environment of cooperation and trust. In this regard, the CSFs will greatly depend on the national and business culture of the country where the concept is to be introduced. Cooperation and trust are more accepted in certain countries and cultures than others.

Thirdly, countries that appreciate issues of environmental sustainability will be more willing to introduce the concept than others, seeing that the concept offers an environmental sustainability benefits in practical terms than other aspects of sustainability according to studies.

In future research, we wish to bring to bear the environmental, social and economic advantages of the synchromodal transportation concept with mathematical models. We wish to compare the advantages with practical situation and real-time data to see which one carries more weight.

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Source: Author.

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Appendix A

Ghana ports performance data

Tema port performance 2003–2015 (GPHA, 2016b).

Years	Vessel call (Units)	Total cargo traffic	Export	Import	Transit	Transhipment	Container traffic
	Tonnes						TEU
2003	1,172	7,391,268	809,589	5,490,893	885,093	138,520	305,868
2004	1,381	8,447,655	1,072,006	6,403,422	764,128	71,082	342,882
2005	1,643	9,249,977	1,182,469	6,936,688	875,325	155,815	392,761
2006	1,994	8,046,838	955,084	5,675,027	887,589	339,841	425,408
2007	1,672	8,378,682	1,099,094	6,120,583	843,656	119,209	489,147
2008	1,568	8,727,049	1,099,094	6,259,412	864,307	195,326	555,009
2009	1,634	7,406,490	1,305,451	5,694,280	509,124	192,565	525,694
2010	1,787	8,696,951	981,075	6,823,488	447,071	236,615	590,147
2011	1,667	10,748,943	1,154,826	8,431,531	614,078	171,195	756,899
2012	1,521	11,468,962	1,532,139	9,383,462	530,457	50,403	824,238
2013	1,553	12,180,615	1,477,390	10,014,243	620,668	51,748	841,989
2014	1,504	11,126,355	1,463,273	8,922,550	577,277	163,305	732,382
2015	1,514	12,145,496	1,303,090	10,043,146	722,508	76,752	782,502

Source: GPHA.

Takoradi port performance (2006–2015) (GPHA, 2016a).

Years	Vessel call (Units)	Total cargo traffic	Export	Import	Transit	Container traffic
	Tonnes					TEU
2006	610	4,720,000	3240000	1,480,000	256,094	51,042
2007	594	4,050,000	2540000	1,510,000	75,599	52,226
2008	615	4,020,000	2330000	1,680,000	209,890	52,372
2009	956	3,370,000	2110000	1,260,000	14,485	47,828
2010	1277	4,010,000	2290000	1,720,000	1,185	53,041
2011	1798	4,940,000	2810000	2,090,000	31,883	56,595
2012	1664	5,310,000	2960000	2,350,000	5,958	60,746
2013	1364	5,450,000	3450000	1,990,000	38,710	52,373
2014	1387	4,750,000	3030000	1,720,000	32,093	61,355
2015	1525	4,700,000	2840000	1860,000	60,250	58,093

Source: GPHA.