A Review on City Logistics and Two Echelon Freight Modelling

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Abstract

When cities are growing in both size and complexity, the freight distribution and management make a significant challenge for transportation management. Freight transportation execution is one of the main sectors that is looked into when planning. The concept of city logistics explicitly tries to optimize the urban transport network and many optimization approaches have been introduced to optimize the vehicle routing methods considering several objectives. Since recent times, there is drawing attention for two-echelon freight consolidation modelling efforts with the emerging of megacities. This paper reviews the available literature under the city logistics modelling, and two-echelon freight consolidation for identifying the perspectives adhered. The study was conducted through a systematic review of literature using multiple studies published under the area of city logistic modeling and two-echelon-distribution modelling in thorough key word base search of city logistic modelling efforts, and performance parameters used for freight analysis within city networks from the findings. The review framework takes into account the diversity and complexity found in city logistics practices. It was evident that there is a lack of modelling efforts in two-echelon vehicle routing for city logistic combining with optimization models for dealing with multiple objective and modeling uncertainty.

Keywords

City logistic modelling, Two-echelon freight consolidation, Logistic performance, Vehicle routing

1. Introduction

City logistics is a major factor influenced by the economy of a country as the demand for goods transportation depend on the nature of economic and social activities. In developing economies, cities are growing in both size and complexities giving rise to the origination of Mega-cities. This will lead to continuous increase in demand for the transportation of goods. With this the local governments are putting the effort to planning the commercial transportation networks in order to minimize the traffic congestion, travel delays and the emissions from the vehicles. Most of the time planning and decision making are done by the freight operating companies and not usually by the public authorities. Nevertheless, less focus is given on the conditions of congestion, travel time and other uncertainties. (Crainic et al., 2004) stated that when organizations manage the distribution it is for the best efficiency of their commercial shippers and they do not consider its impact it may have for the city transportation in general.

Freight transportation is one of the main sectors looked into in city logistics when planning but less attention is given to this as more focus has been given to general city routes planning. As delivery times are becoming crucial with the growing demands it is vital that the freight transportation is planned with minimum delays with short travel times. Therefore, it is necessary to identify the bottlenecks that inflate the logistic cost, simplify the process and reduce overall logistic costs. Several optimization approaches have been introduced to optimize the vehicle routing methods

of city logistics, in order to minimize the congestion and provide an efficient delivery, while meeting the constraints like repetitive travelling and multiple depots etc.

Urban freight transportation can be a very disturbing activity sometimes as it utilizes the same road network available for passenger transportation. Therefore, these vehicles make a considerable contribution for the road congestion and variability in travel times. And this problem keeps rising as significant volume of freight vehicles keep moving around the city limits. According to the Sri Lanka Transport sector policy note, the port related traffic accounts for an average of around 35,000 truck trips per week while the destinations of the import cargo is mostly within its metropolitan city of Colombo which is expected to grow. However, there is still a lack of coordination and control of distribution activities. There have been efforts taken on city logistic modelling and most of these are based on case studies relevant to particular geographical behaviours and also taking approaches in technological perspectives of linking intelligent transport systems to capture real time information. In this paper the available work will be reviewed and the sections are organized as follows. Section two will describe the methodology used for the systematic review, section three will deliver the main outputs with the perspectives of the authors and the objectives targeted. The final section will review the modelling efforts under both city logistics and two echelon freight modelling and present the conclusion.

2. Methodology

The systematic review was based on the content analysis of the main domain areas of city logistics modelling, two-echelon freight consolidation and vehicle routing. The initial step was to gather literature available under the mentioned areas. Review on city logistics models was done based on the on the articles where its objective was to increase efficiency. For this the selection of the papers was partly based on the review of city logistic models Anand. et al. (2012) up to year 2010 and keyword based search for city logistic models and two echelon freight consolidation and modelling and vehicle routing. After the initial screening based on abstracts twenty articles were selected and full text review was done for the selected papers. Most of the papers selected were published after the year 2000.
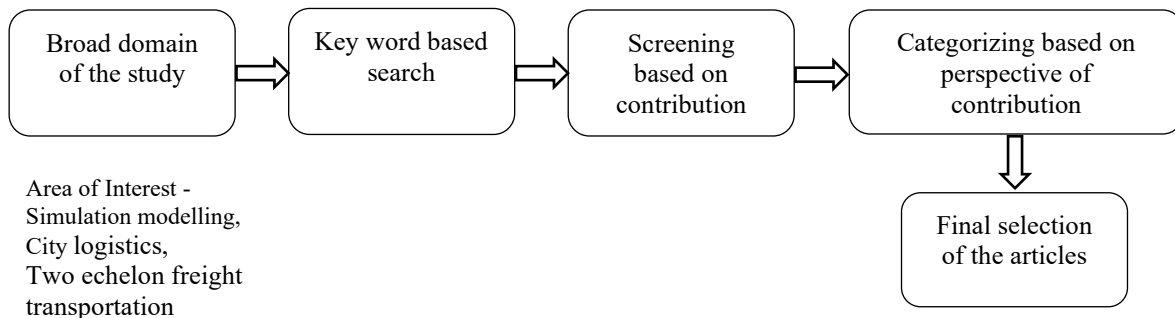
Figure 1 - Screening process of the systematic literature of review

3. Results of the literature review

The review of literature illustrates various types of modeling efforts that exist for city logistics analysis. With the variety of concepts of urban freight, the methods and tools used for research also varies widely.

This chapter presents the summary of the research articles reviewed under each area relevant for the study. The articles have addressed one or more areas which have been considered in this study. Below we explain and review city logistics modeling efforts are reviewed according to perspective adopted and the selected two-echelon freight consolidation and vehicle routing.

City logistics explicitly tries to optimize the urban transport network and according to Anand et al. (2012) it is vital to have an understanding about the interactions among different stakeholders. Recently there is increasing attention paid for the two echelon freight consolidation distribution planning and analysis, but still there is a lack of modelling efforts for vehicle routing optimization under this for city logistics.

The main component of the logistics is the physical distribution of goods which involves flowing of products in a transportation network via hubs. Though it does not add value it is a very costly operation (Montoya-Torres et al., 2015).

Anand et al. (2012) while attempting to understand interactions among different stakeholders for fulfilling (supply) goods and services demand, provides insights in urban goods movement causes.

Urban freight transportation modelling lacks appropriate behavioural approach towards modelling related processes Regan et al., (2001).

An integrative framework was proposed with the idea of depicting full problem of freight movement combining two aspects, the user side based commodity model and logistic decision side based vehicle trip model. This included various actors like producers, consumers, carriers and regulatory bodies. The framework was presented with a technological perspective targeting a simulation model but was not tested. Its main focus was given for the economic factors and was more appropriate when the freights were competing in all origin and destination pairs. (Holguin-Veras 2000).

(Taniguchi and Shimamoto 2004) presented a dynamic vehicle routing and scheduling model with real time traffic information transferred from intelligent transport systems in particular to deal with variable travel times which took a technology based approach. They came up with two models for vehicle routing one with forecasted travel time (VRPTW-F) and the other presented based on the real time information on travel times (VRPTW-D). It further states that there is limited research done under variable travel times as many researches have focused on the variation of customer demands.

A demand-driven, commodity-based freight movement model was proposed by Boerkamps et al. (2000) which included the supply chains. It was based on the behaviour of the actors involved. The conceptual framework was named as 'GoodTrip' model and it is a general model built, by incorporating the most important linkages in the supply chain such as the consumer demands. The model estimates goods flows and simulates vehicle tours to facilitate transport demand. It suggests that actors can outsource its transportation responsibility to third parties such as transporters and logistic service providers while highlighting the requirement for having coordination within the road networks.

Ruso and Comi (2002), discussed a model based on purchase choice and trip based model considering the type of commodities being transported for analyzing urban goods traffic which again took a behavioural perspective to model the freight movements considering the approaches taken by different geographic settings.

Literature reported on a prototype developed a prototype with dynamic assignment of travel times to the network links. Travel time is the elementary parameter used to represent traffic conditions in the network. This parameter reflects both the normal daily dynamics of the network, and the impact of incidents. Travel times on different links can be correlated when certain circumstances are encountered. For example, traffic conditions may be affected by the weather: on a rainy, foggy or snow etc. The simulation model was developed with a technological perspective to facilitate efficiency. (Xu J. et al 2003).

(Craniac et al. 2004) Organizational and technological frame is presented from the planning perspective and highlight need of control and coordination from the authorities. It also presented a branch-and-bound mathematical model for location allocation for the satellites. Satellites or satellite platforms are "where the freight coming from various external points could be transferred and consolidated into environment-friendly vehicles adapted for utilization in dense city zones." This was carried out to present a mathematical model which had the objective to aid in planning.

A simulation model on a test road network is presented considering different policy measures like truck ban and tolling on expressway. This study tested the effect on several stakeholders like shippers, carriers and administrators. However, not much of extra benefits were shown to satisfy all the stakeholders considered. (Tanaguchi and Tamagawa 2005).

Two-echelon vehicle routing problem is an extension of the classic vehicle routing problem which was has extensive attraction in the field of two-echelon logistic optimization.

Craniac et al. (2009) discus the planning issues available in city logistics and presented a mathematical model for the day-before-planning problem for the optimization process integrating the concept of city distribution centers. They also highlights the little attention given for evaluating and planning of two- tier city logistic systems. The study was carried out in the perspective of planning.

Most research in the area of transportation modelling has focused on dynamic routing and scheduling that considers variations in customer demands. However, there has been limited research on routing and scheduling with variable travel times (Taniguchi et al., 1999).

Wang et al. (2018) presented a hybrid metaheuristic algorithm with ant-colony algorithm and Improved Particle swamp optimization model for two-echelon logistics delivery and pick up through showing the cost effectiveness in having collaboration. The mathematical model aimed cost saving. It also highlights the need of cooperative multiple

alliance in sharing transportation resources to reduce overall operating cost thereby moving to a one grand alliance for more efficient and reliable operation. But It also mention the little attention which was given when implementing this in the field and did not account for the road network conditions.

In year 2011 Craniac et al. (2011) developed a new approach to the two-echelon freight distribution by addressing it as two-echelon location routing problem where it simultaneously determines the location of facilities of the adjacent echelons. It was developed as a mixed integer programming for the basic model.

Through the papers reviewed it was evident that there is a lack of modelling efforts in two-echelon freight modelling and vehicle routing for city logistics for optimization models to account for uncertainties like variable travel times and most of the models available focused from the customer end and its variability in demands.

A metaheuristic approach through a mixed integer linear programming model was presented by Yang and Zeng (2018) which considered time constraints in city logistics considering up to instance on thousand customers. This also considered the approach from the time demand arising from the customer end.

4. Discussion

According to a study done by Freight Transport Association (FTA) six factors were identified as important parameters or indicators in developing planning strategies for freight transportation (Freight Transport Association, 2000). And one of them is Routing of flows: This defines the pattern of flow at different spatial scales. Scheduling of deliveries: This determines the flow of freight traffic through time where there is a lot of opportunities.

Traffic levels and their impacts on towns and cities across the world have received growing attention in recent years. Much of it has been directed at public transport and private car traffic while relatively little consideration has been paid to road freight transport (Browne and Allen, 2011).

How to create more efficient urban freight operations and how to reduce its negative externalities are the main questions and city logistics focuses on improving the efficiency of urban freight transportation, while reducing traffic congestion and lessening environmental impacts.

However, when it comes to city logistic modelling it is complex as the network may have multiple depots where demand rises and many nodes where consolidation of goods. Also in city planning there may be multiple travel modes available to increase efficiency of road network as well different transportation policies adapted.

At the planning level, the objectives are the cost reduction and increasing efficiency and reliability as transportation cost is something that can be directly controllable within a network. Also at the operational level there can be factors affecting which have an impact on this identified cost, efficiency and reliability.

In facilitating these objectives, one of the main key things to consider would be the short delivery time between the hubs and the destinations and facilitating speedy turnaround times. In order to arrange the transportation network in a way that it will reduce the travel delay, the parameters which are causing this have to be identified. This will lead to the area of identifying proper logistic performance parameters to analyze and plan the requirement which will in return assist the authorities in operationalizing its urban logistic plan.

When it comes to optimization of two-echelon vehicle routing, methodologies based on operations of city logistics are lacking except for some advanced technology based methods such as using intelligent transport systems and technological perspectives. According to (Crainic et. al 2004) two-tier systems have been proposed recently and according to them there are few studies dedicated for the evaluation and planning of them and no models are yet to be found.

According to (D'Este G. 2007) the pattern of urban freight activities exhibits significant variations by time of day and season of the year. It further states that surveys have shown that the activity between the freight sector and the passenger activities are different. Therefore, accounting for these variations may make a significant difference in operationalizing the models.

Considering the different perspectives used in freight consolidation and city logistic modelling it is challenging problem and the real issue would be in finding a solution to optimize the two tier network for improved performance. This is because of the difficulty in connecting the two echelons by finding a more efficient procedure.

From the papers reviewed it was evident that there is a gap of research available for two-echelon vehicle routing optimization models for city logistics to account for uncertainties like variable travel times and most of the models available focused from the customers' point of view and its variability in demands. *Figure 1* summarizes the modelling perspectives reviewed during the study in terms of city logistics modelling and the hierarchical level of distribution adhered.
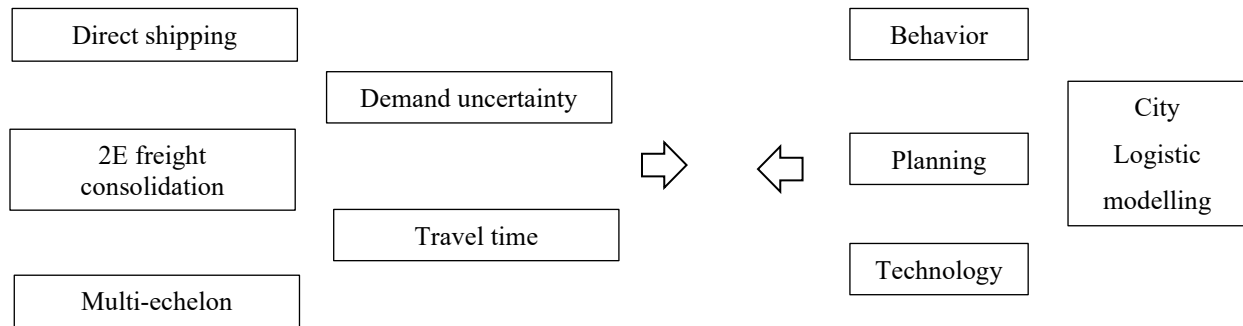
Direct shipping		Behavior	
	Demand uncertainty		City Logistic modelling
2E freight consolidation		Planning	
	Travel time		
Multi-echelon		Technology	

Figure 2 – Overview on the modelling perspectives of the review

5. Conclusion

This paper reviewed the literature available under two main areas. City logistics modelling and urban freight routing and optimization and identified the available approaches taken in terms of the modelling perspectives. It was found that there is a gap existing in modelling and optimizing using the multi objective and uncertainty for two-echelon city logistic modelling. Mostly the models and frameworks discussed here tries to link the end to supply chains and highlights the importance of integrating all the stakeholders in planning. but the attention to optimization of road network in two echelon vehicle routing under city logistics needs to be improved. Also on the other extreme there is optimization approaches looking to advanced freight distribution systems. However, there are many stages to be considered before these are fully employed and still there are challenges for a methodology in planning and building an operational model. It was identified that less attention has been given to modelling the effects of dynamic environments within a road network, variability of travel times and road capacity. The effect of different transportation scenarios will be further researched through a development of a simulation model.

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