Accounting for Transport and Logistics Hubs in Freight Demand Models

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Abstract: The importance of logistics and its impact on transport processes were considered when modeling the demand for freight transport using new models that include several aspects. However, transport logistics hubs without a storage function, which are mainly used for cargo transshipment, are not sufficiently accounted for in most cargo models, although they are of great importance for cargo transportation. Currently, it is not clear which models actually take into account transport and logistics hubs and how they do it. The purpose of this article is to review the accounting of transport and logistics hubs in models of demand for cargo transportation.

1 INTRODUCTION

Until a few years ago, logistics elements were considered incomplete or not considered at all in most national models. This made it difficult to accurately map freight transport and logistics as a factor affecting imports. The following will provide an overview of developments in freight transport modeling related to logistics integration. It will provide a general basis for the subsequent presentation of various models that consider logistics and transport logistics hubs in particular.

2 MATERIALS AND METHODS

Early attempts to integrate logistics aspects into models can be found in the field of disaggregated modeling, both related to method selection and logistics selection.

There are various models that take logistics into account. Although transport demand modeling in relation to logistics issues has been greatly developed in recent years, only a few models are currently used that specifically include logistics aspects (Golubchik, 2020). Some examples can be found in the British EUNET, in Dutch SMILE or in SLAM implemented in SCENES the European model. A striking example in this area is the national transport model system implemented in Sweden and Norway (SAMGODS and NEMO) (Mirotin, 2019).

Model applied to a region of Sweden named SAMGODS, is a model of national resolution and macroscopic scale analysis. From a certain point of view, it can be considered as a mixed model, if we talk about its depth of aggregation. The model is based on several submodels that take into account the development of the economy and trade, from which it deduces the flow generation. The model takes into account 35 product groups and offers 86 predefined transport chains for transport processes through a multimodal network. Permission for cargo size, suitable routes and means of transportation is made using the logistics module (Ushko, 2019).

The logistics module consists of three stages and follows the "aggregated-disaggregated-aggregated" structure. Flows of goods between places of production and consumption are primarily provided at the aggregate level. In order to assign them to individual firms, they are disaggregated. Consequently, firm's logistics decisions (e.g., shipment size, use of collection and distribution centers) can be modeled in this disaggregated part of the model.

By selecting one of the predefined transport chains, the logistics module sets the modes of transport for each section and determines how transportation is carried out (directly or through the use of logistics nodes). The model also includes transport and logistics hubs defined as cargo transshipment and possible storage locations (Gubanova, 2009). The logistics module consists of subprograms that gradually develop solutions.

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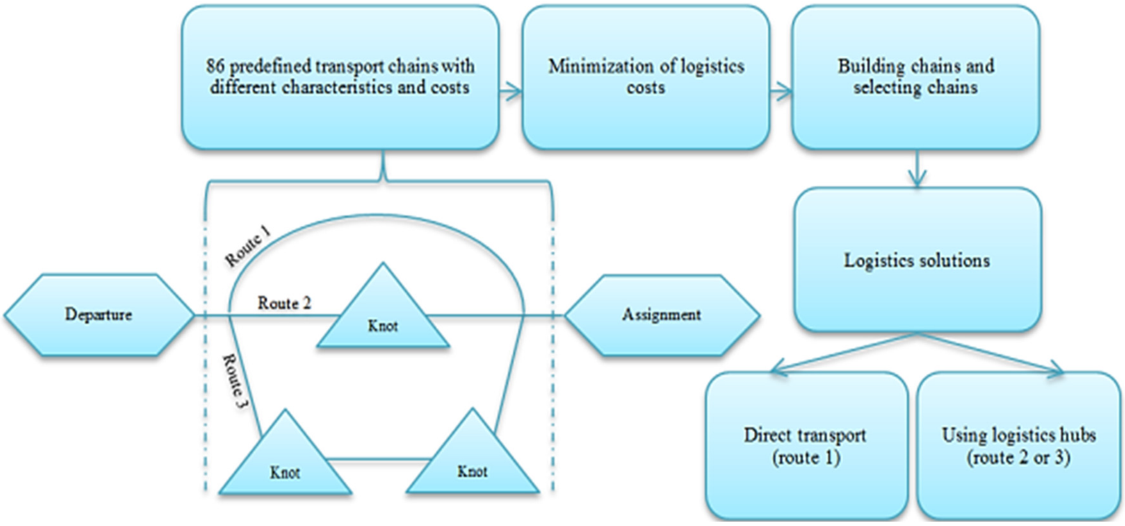

Figure 1: Integration of logistics hubs in SAMGODS.

Therefore, the available transport chains, including optimal transfer points between transport sections, are initially generated in the first subroutine. This is followed by the second one, which selects transport chains based on minimizing overall logistics costs, shown in Figure 1.

NEMO is the national model used in Norway. Due to its evolution (parallel toSAMGODS), NEMO views logistics centers in a similar way to SAMGODS. Thus, the model is an extension of the Swedish model to the spatial domain of Norway (de Jong G, 2007).

The Dutch SMILE model, which predicts traffic flows at the national level, was one of the first models to take logistics aspects into account.

SMILE models traffic flows by taking into account economic events and linking the economy, logistics, and transportation.

Figure 2 shows the combination of logistics nodes, which in this case are represented by distribution centers, becomes noticeable when considering the characteristics of the nodes, as well as the attributes of goods and their requirements in terms of inventory, processing and transportation (Gruzdev, 2021).

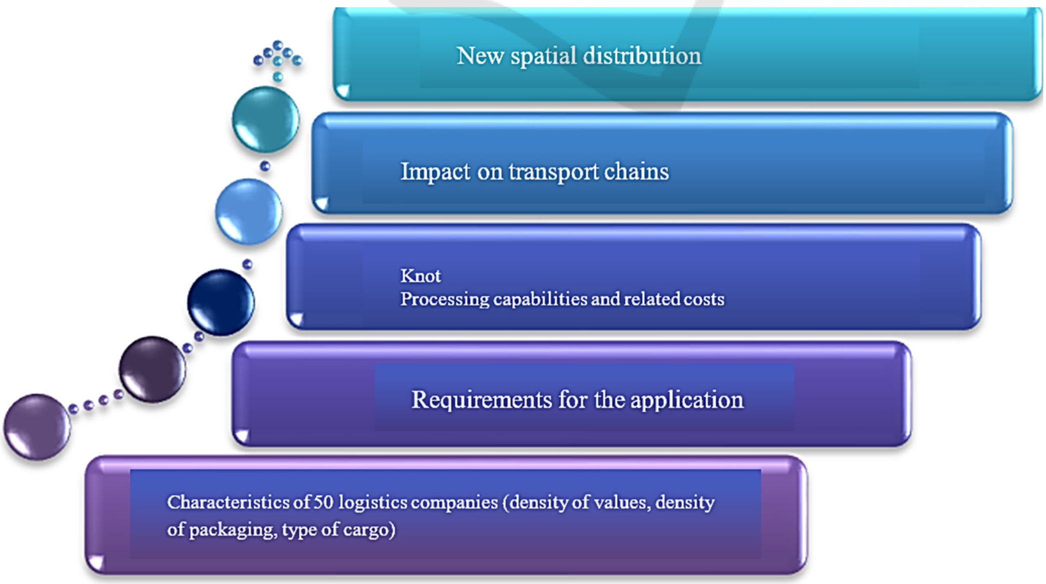

Figure 2: Node in SMILE.

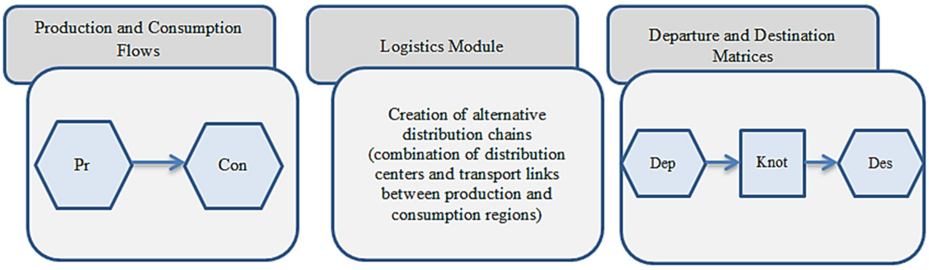

Figure 3: Node in SLAM.

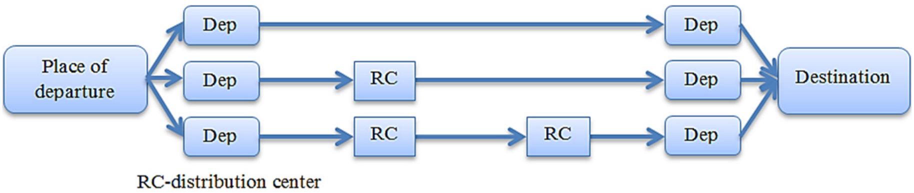

Figure 4: Nodes in EUNET.

SLAM is integrated into the European SCENES model. The main ideas and experience of the Dutch SMILE model were used in the development SMILE process. SLAM is designed to assess the impact of changes in logistics and transport systems across Europe. Therefore, one of the main applications is the discovery and location of distribution centers in Europe. The SLAM model takes into account changes in distribution structures (for example, the number and location of intermediate warehouses used for distribution) and includes them in distribution flows (Avramchikova, 2019).

SLAM obtains production and consumption flows that integrate alternative distribution chains. In this context, the distribution chain is defined as a set of distribution centers and transport links for trade flows between the producing region and the consumer. Thus, the main function of the model is to consider alternative distribution chains (production – distribution center – consumption). The model is shown in Figure 3 (Musatov, 2019).

SLAM achieves a more accurate picture of traffic flows by integrating distribution logistics nodes into the transport system. SLAM does not go into details about networks, since flows are strictly economically rational and pass through an abstract distribution-consumption network in the most cost-effective way (de Jong G, 2007).

EUNET is a regional model developed in the UK. It covers freight traffic in the central part of the UK, as well as imports and exports from and to the region. The purpose of the model is to predict the demand for cargo transportation depending on economic operations and cargo logistics (Rustamov, 2021).

Thus, there is a set of distribution channels through a set of possible nodes, shown in Figure 4.

The LAMTA freight forecasting model is a multimodal transportation demand model shown in Figure 5.

While the model primarily focuses on road freight transport (cargo transportation), it also includes a multi-modal framework to support cargo transportation solutions and logistics hubs.

GoodTrip – is an urban freight transport model used in the Netherlands. It is based on consumer demand: it builds logistics chains, linking the activities of consumers, supermarkets, hypermarkets, distribution centers and manufacturers.

The four-component model (spatial organization of activities, cargo flows, transport, and infrastructure) calculates the volume of goods by product group for each spatially defined zone. Thus, the flow of goods between consumers and producers is determined. Within this definition, product flows are affected by both the spatial distribution of activities, and the market share of each group of activities (consumers). After that, the product groups are classified and a matrix is created. At the final stage, vehicle trips are generated and assigned to the network (de Jong G, 2007).

Although the model takes into account logistics aspects, transport logistics hubs are not fully covered (loading facilities or similar objects). Approaches to the concept of urban distribution centers can be considered in various scenarios. One example here is the scenarios for urban logistics distribution centers shown in Figure 6.

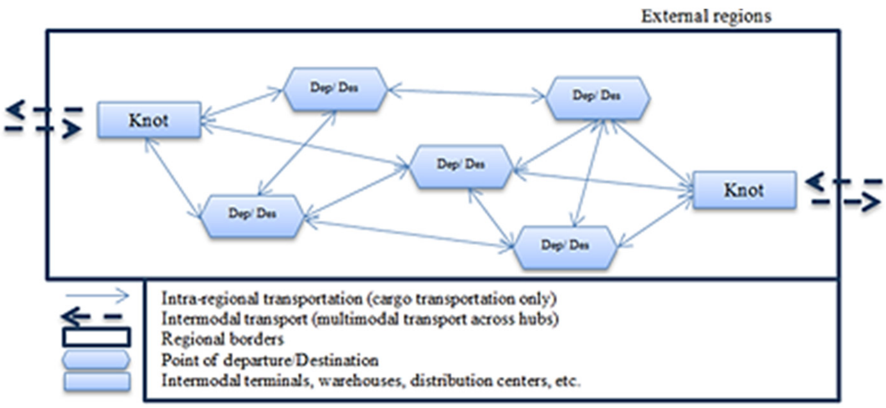

Figure 5: Nodes in LAMTA.

However, the influence of logistics hubs in general and transport logistics hubs in particular on transport within the study area is ignored from a large-scale point of view. To summarize the understanding of various models, it can be stated that there are various ways to integrate transport and logistics nodes into modeling.

A fairly simple method is to integrate nodes as sources and sinks in models. Thus, logistics nodes are considered in a simple way as so-called special generators or singular flow generators, the volume of transport of which is supplied from outside.

Integration of transport logistics nodes using logistics modules that choose between several predefined transport chains is a more complex method. The properties of shipments (for example, goods, shipment size) have a decisive influence on the consideration of nodes within logistics modules. Due to the peculiarities of the nodes, there are often restrictions in the handling of certain goods. If the nodes are not suitable for handling certain loads, the probability of transportation through these nodes will be reduced. The result of this consideration are various transport chains processed only through certain nodes. Thus, the characteristics of nodes in combination with the characteristics of transportation determine the use and impact of nodes or transport demand, respectively. Another aspect of the integration of logistics nodes into the simulation is the inclusion of additional characteristics of nodes that exceed the characteristics (the ability to handle certain loads). For example, integrating information about differences in the technologies used in nodes can be very useful if the technologies used differ significantly. This method makes it possible to examine the hubs in more detail if they differ in their characteristics.

At the same time, it is necessary to understand what data could help to achieve adequate integration of transport logistics hubs in the modeling of transport demand. Such data should contain information about the characteristics of the node (for example, total area, capacity, branches of customers), as well as information about the transport process

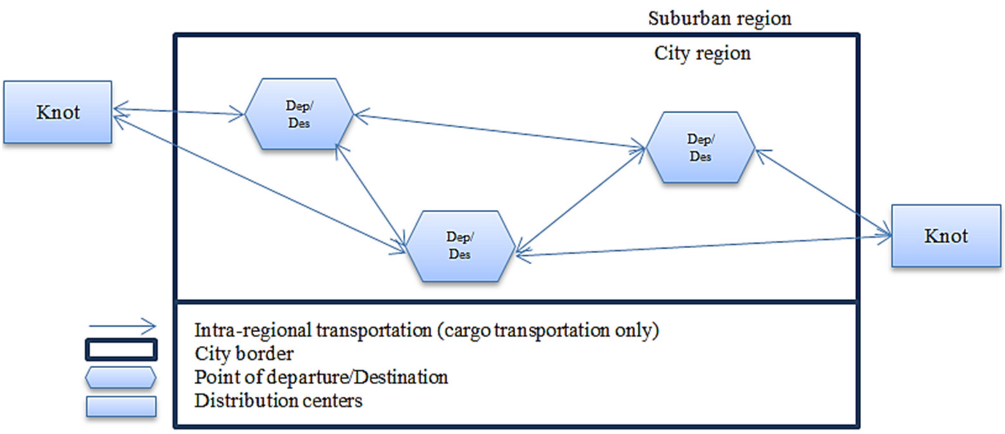

Figure 6: Nodes in GoodTrip.

Table 1: Opportunities for improving the integration of transport and logistics hubs.

Important attributes that characterize transport and logistics hubs	
Basic node data (e.g. area)	Vehicles
Total area	Transport facilities
Processing area	Infrastructure connection
Bandwidth	Customer branches
Number of trips	Loading units and loading and unloading facilities
Number of vehicles	Volume of traffic
Transportation distance	Type of business
Network structure	Empty trips and capacity utilization

itself (for example, vehicles, transport facilities, volume of traffic). This additional information will improve the integration of transport and logistics hubs (Table 1). The data is presented in table 1.

The use of new data containing the above attributes will help to deduce key parameters in order to identify correlations and dependencies between certain node characteristics and the specific role of nodes in the transport process.

3 RESULTS

The article examines the integration of transport and logistics hubs in the model of demand for freight transportation. It is revealed that the growing relevance of logistics in freight transportation in recent decades is taken into account in demand modeling due to the greater integration of logistics aspects into some models. This development was important because models are relevant tools for forecasting transport demand and supporting decision makers through the evaluation of transport policy measures. However, the analysis showed that, although the demand models for freight transport have undergone significant improvements in recent decades, important logistical aspects have not yet been sufficiently taken into account.

4 CONCLUSIONS

Within the framework of cargo transportation processes, transport and logistics hubs have recently become increasingly important empirically. This implies a greater relevance of their consideration in demand modeling. Nevertheless, the conducted review showed that the accounting of transport and logistics hubs when modeling the demand for freight transportation differs significantly. Most of the existing freight transport models do not integrate transport and logistics hubs. Application models in many cases focus on distribution logistics hubs, but only a few integrate transport logistics hubs to some extent.

Thus, the integration of transport and logistics hubs differs in many ways. Firstly, not all types are considered models. Secondly, the consideration differs not only quantitatively, but also qualitatively.

There are also certain restrictions that prevent node integration. The potential of many models is limited due to the availability of data. More detailed data is needed for node integration. The lack of adequate and detailed data remains a serious problem.

To solve these problems and achieve greater realism, transport logistics hubs should be highlighted in the modelling of demand for freight transportation, as well as in empiricism.

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