Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 39 (2012) 534 – 542

Procedia
Social and Behavioral Sciences

The Seventh International Conference on City Logistics

A commodity distribution model for a multi-agent freight system

Wisinee Wisetjindawat[a*], Koshi Yamamoto[a], Fabrice Marchal[b]

[a]*Nagoya Institute of Technology, Gokiso, Showa, Nagoya 466-8555, Japan*
[b]*Laboratory of Transportation Economics (LET),14 Berthelot, Lyon 69363 France*

Abstract

Modeling transportation systems at the microscopic level is currently gaining favor among researchers throughout the world. A multi-agent system, which is one method of microscopic modeling, is a dynamic framework dealing with the behavior of each individual actor in the transport system, and is especially favored for passenger transport models. Likewise, freight systems need a similar framework to better represent the interactions amongst freight agents, as large numbers of heterogeneous freight actors and other factors are involved. This paper proposes an extension of a multi-agent transport modeling system to cover the area of freight movement. The focus of this paper is at the stage of commodity distribution, in order to model the links between suppliers and receivers of commodities. The model is developed based on the principal of commodity movement through supply chains. The structure is a demand derived model, where receivers are the decision makers who choose their suppliers. The model is constructed based on the discrete choice method, considering the constraints of the amount of the commodity generated and the amount desired by each of the companies, travel impedance and attractive factors of the shippers. The model is developed and applied to the movement of urban freight in the Tokyo Metropolitan Area.

Keywords: Freight demand model; behavioral model; multi-agent; commodity distribution

* Corresponding author. Tel.: +81-52-7357423; fax: +81-52-7357423.
E-mail address: wisinee@nitech.ac.jp

 doi:10.1016/j.sbspro.2012.03.128

1. Introduction

The development of freight modeling lags behind that of passenger transport for several reasons. First, modeling a freight system is a very difficult task because of its complexity. Freight movement involves complicated linkages among many freight agents interacting in supply chains. A number of freight agents (eg. shippers, receivers, dispatchers, and drivers) act as decision makers in different situations. For purchasing and delivery, a receiver decides its own suppliers and the amounts of commodities required, while shippers (and sometimes together with the receiver) decide the shipment size and dispatch choice. If the delivery involves with third party logistics (3PL), the dispatcher becomes the decision maker who decides the mode of transportation and the organization of the delivery. A further complication is due to the heterogeneity of the freight system, whereby the characteristics of commodities vary in volume, weight, value, and shape. In addition to the complexity, another modeling challenge is limited data availability, due in large part to privacy issues. In addition, current innovations in freight movement, such as Just-In-Time and third-party logistics, adopted in several freight organizations need to be considered when modeling freight systems. The microscopic modeling approach is currently gaining more favor in both passenger and freight demand modeling. The multi-agent system, which is one microscopic modeling method, is found to be suitable for modeling freight systems since it can better reflect the real mechanism of movement. The complicated interactions among freight agents can be expressed better through a multi-agent system.

When creating a multi-agent model of freight movement, a module to identify the shipper and the receiver of each shipment is necessary. An earlier modeling method is a freight distribution model based on the traditional four-step approach, generally based on a gravity model. Gravity models calculate the flows (either in terms of numbers of trips or tons of commodities) between each origin and destination pair as a function of generation and attraction of the origin and destination zones weighted by an impedance term that represents transport costs between the zones of the pair. This technique is, however, dealing with freight movement at the zonal level and, therefore, not suitable to be applied in a multi-agent system where single shipments are considered.

One of the biggest obstacles for developing multi-agent freight system for the commodity distribution part is to identify the connection between each pair of shipper and customer. At present, there are many models developed using logit model for calculating the fractions. However, the question is to calibrate that kind of model, one need to know exactly which the shipper for each customer. This is obviously impossible to be obtained this detailed data in reality. The objective of this study is therefore to develop a commodity distribution model for a multi-agent system to overcome the problem of data availability for model calibration. The model is based on the decisions of each individual customer on purchasing commodities from each individual shipper. The commodity distribution can be viewed as a supplier location choice model to which a discrete choice model can be applied. The commodity flows between shippers and customers are calculated based on a logit model, constrained by the amount of the commodity generated and attracted by each of the companies considering the distance between companies and attractive factors of the shippers. The model is developed and applied for the urban freight movement in the Tokyo Metropolitan Area.

1.1. Development of freight models

Several approaches have been proposed to model freight systems. The earliest approach was to model freight movement together with passenger movement by introducing a percentage to represent freight vehicles from the passenger trips. Another development stream tries to consider freight characteristics into the modeling. These models are called the “input-output model” where monetary flows between each