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A framework for incorporating market interactions in an agent based model for freight transport

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Abstract

A model is sketched that allows to display the reaction of the supply side in the freight transport market on changes in demand and on policy measures. Considerations are made on how to include the concept of monopolistic competition into an agent based market simulation. Methods of price formation and rules for entries and exits of suppliers in the market are given.

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Keywords: Freight Transport; Market Model; Monopolistic Competition

1. Introduction

Freight transportation requires the interaction of a multitude of actors. This holds true for the relationships between shippers and recipients as well as for their business connections with transport companies. However, interactions between single actors alone cannot explain the observable movements of heavy goods vehicles, nor can information on such movements be traced back to single interactions. Thus, there is an apparent mismatch between observed respective observable states in the transport networks and the behavior of single actors involved in freight transport.

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Research has identified two main reasons for this gap between individual behavior and the behavior of the transport system. The first one is the necessity of coordination between the involved companies. On the demand side of the freight transport market, companies often do not act independently, as they are part of logistic chains. These chains become more efficient if the involved parties on all chain links collaborate. Collaboration on all chain links means that the requirements of all concerned companies are passed on through the chain and that the actions of single companies implicitly take the requirements of all other actors into account. Moreover, logistic chains have to adapt to requirements from outside. In many cases transport services are performed by a transport company and not by the shippers or recipients. Additional outside influences on logistic chains in these cases are the actions taken by transport companies.

The existence of an own business sector for freight transport is the second reason for the gap mentioned above. Single transport companies optimize the freight flows of many logistic chains. At the same time, competition on the market forces them to operate at the lowest possible costs given the requirements of their customers. For this purpose, they maintain networks of facilities to fulfil transport tasks in a competitive way. In particular smaller shipments are not suitable to be transferred directly from the shipper to the recipient but rather have to be fed in such networks. These networks entail vehicle movements that deviate from the original flows of goods, as such deviations are cost minimizing given all the orders handed over to a certain transport company.

Movements of freight transport vehicles are thus the result of the continuous adaptation of many actors to each other. This adaptation goes along with phenomena of emergence that influence the observable traffic flows. Moreover, emergent phenomena can lead to changes in the structure of demand and supply on the transport market that are also partially observable. One of these changes is the entry and exit of transport companies in a certain market segment. We want to address such emergence by composing a transport market of its constituent parts. For these purpose, we want to outline an approach to model the interactions between supply and demand on the market for mixed cargo. With supply, transport companies are meant that carry shipments on their own account. The demand side is represented by shippers and recipients of goods. As decisions are drawn decentralized on such a market, agent based simulation will be employed. Agents are to a certain extent heterogeneous, pursue their own goals and adjust to the influences of the market. From the behavior of single agents, the market outcome and thus the generation of vehicle movements will be put together. A specification for a model to be implemented is sketched in which some aspects on the intersection of transport demand modelling and microeconomics will be dealt with. The present paper will outline a model for a market under monopolistic competition. The reason for the choice of this market form is that some properties of the suppliers, i.e. the transport companies will be explained endogenously by the model.

2. Literature overview

There are many scientific disciplines that deal with the interactions of a system and the parts that it is comprised of. Many of such interactions have been described quantitatively in natural sciences, such as physics. From there, concepts were transferred to social sciences in general and economics in particular (c.f. Weidlich (2006)). In such models, single actors take into account the behavior of their environment to varying extents. Models in which actors explicitly anticipate the actions of all other players also occur in industrial organization that uses game theoretical concepts to study the connection between a market and the firms that are active there.

Such approaches try to look for solutions in closed form. In more complex settings this is not possible anymore, so that it is resorted to simulation models, in which a myriad of possible system states can be displayed in comparatively short time. In social sciences, agent based models have been used to address situations in which the state of a collective of individuals has to be explained from the decisions that single members of this collective draw. For the special case of economic models an own branch of research called Agent Based Computational Economics (ACE) has emerged. Tesfatsion (2006, p. 835) states “ACE is the computational study of economic processes modelled as dynamic systems of interacting agents”. Agents in the sense of Wooldridge & Jennings (1995) are computer systems that can act autonomously to reach a certain predefined goal.

Models of market simulation have already been applied to transport markets in the past. One of the first of them is the one of Holguin-Veras (2000). Starting from the assumption of Cournot competition between two carriers, vehicle tours are built, so that all transport demand can be satisfied and both carriers maximize their profits. Dimitriou and Stathopoulos (2009) also model oligopolistic behavior in the competition between three maritime container terminals