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An Agent Based Simulated Goods Exchange Market; A Prerequisite For Freight Transport Modeling

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Abstract

Freight flows are in essence a result from the exchange of goods between producers and consumers and the transporting firms moving the goods. This essentially constitutes a market interaction among different type of firms, differentiated by many attributes like industry type, size, location and role in the supply chain. A usual final outcome of such an interaction manifests itself in the form of Production-Consumption (PC) matrices, tabulating regional production and consumption pairs for the different goods and geographical region being simulated. It is often the case that this information is obtained only at an aggregate level, either due to firms' unwillingness to share their trading information or the high cost of obtaining this data or both. Different techniques are used to disaggregate such data. This process often implies over simplified assumptions. In this paper we present a bottom up approach to simulate this goods interchange process between production and consumption firms. The proposed model is based on an offer negotiation and evaluation process among three types of firms; production firms, consumption firms and carrying (transport) firms. The interaction is based on actual firms' decisions. Agent based simulation technique is used to facilitate capturing some behavioral aspects of the different agents (firms) in the model. One outcome of this model is a set of PC matrices which can be used in further transport modelling steps.

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1. Introduction

The primary goal of operational freight transport models is to serve as a planning tool for policy makers. Transport domain policy makers use such models to better assess decisions on e.g. infrastructure expansion or maintenance, effect of tolls or fuel price effect on modal splits[1, 2]. Traditionally, freight transport models borrowed elements from private transport models, namely; the four steps modelling approach. However, this approach – when applied for freight transport modelling – has a main limitation; it fails to capture important behavioral aspects directly linked with the amount of goods generated, transported and consumed[3, 4]. The subject four modelling steps (as used to model freight flows) are; production and attraction, distribution, mode choice and network assignments. Of special importance to us here are the first two steps of this traditional approach.

The production and attraction step is in essence the aggregation of total regional production and consumption quantities, expressed normally in tons. These are local totals produced and consumed in each division (geographical zone) of the study area with no underlying rule to match both sides. It is in the next step; distribution, where a mechanism to match production and consumption is used and from which, detailed goods exchange relations among zones is tabulated. Resulting tables are often called Production-Consumption PC matrices[5]. Both steps basically represent a good exchange market between firms producing the goods, final consuming parties (e.g. firms, individuals, government), and the transport firms who actually transport the goods among them.

The elements, motives, distributed decisions making processes and interconnected relationships in a real life economy are quite complex. However, if we limit ourselves to the objective of simulating goods flows, then we can focus only on those firms' activities which affect this final goal. Specifically, we would care about those firms decisions \ activities which influence the amount and location of goods being produced and consumed, basis to link both sides, size and frequency of shipments, mode choices and network usage.

With advancements in processing power and the emergence of new simulation techniques, a new generation of freight and logistics models came into existence, overcoming some drawbacks of the four steps modelling approach. Nevertheless, existing modelling efforts still suffer from the following:

- *Lack of data*:

Lack of disaggregate data on firms often drives modelers to use different disaggregation techniques in their models, which often implies making over simplified assumptions. Examples of such assumptions are made in [6], where the number of firms per geographical zone – and classified into size categories- have a "one size fits all" predefined rule of interaction. Another such an assumption is made in [7], where all goods producing entities and consuming entities are each represented by one agent in a given geographical zone. This assumption - although justified by lack of more detailed data- clearly prevents the model from fully exploiting the power of agent based simulation techniques. Lack of data is also the main reason why some modelling efforts stopped at providing conceptual model frameworks and did not enter the phase of implementation [8, 9].

- *Weak behavioral foundation*:

Existing operational models involving firm to firm interactions and firms decisions, rarely link their model assumptions to theories of individual \ firms decision making. Instead the assumptions – still logical of course- made often serve an operational goal of having a model that functions. In economics, there exists today a wide range of theories on decision making processes for individuals and firms alike. Examples are Utility Theory (UT), a more recent and formal version of UT; Expected Utility Theory (EUT) [10], Prospect Theory (PT) [11] and related concepts of perfect versus bounded rationality. Several of these theories and concepts have been empirically proven and even formally defined. Therefore borrowing elements from this theoretical foundation will enable modelers design more trustworthy models.

In this paper, we address the lack of data problem by proposing a bottom-up approach to generate PC matrices. More specifically, we propose an agent based simulated goods exchange market model, where the agents are the different firms producing, consuming and transporting goods. Availability of disaggregate data on firms and using