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Analysis of mode choice variables in short-distance intermodal freight transport using an agent-based model

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ABSTRACT

Medium to long-distance intermodal transport has been strongly promoted by the European Commission and national governments as a solution for ensuring the sustainability of the freight transport sector. However, so far, intermodal transport has revealed limited capacity for competing against road transport. New solutions aimed at expanding the limits of its competitiveness are needed. Some successful cases of short-distance intermodal transport reveal untapped market opportunities.

The literature on mode choice fails to explain these successes. The research has focused mainly on long-distance services, and the findings are not necessarily transferable to the short-distance transport. This paper presents the results of research aimed at testing this assumption.

A new agent-based model to simulate the transport operations and behavioural reactions of transport agents was developed, applying mode choice variables that are consensually referred to as pivotal in the mode choice process: price, transit time, reliability and flexibility. The use of the model was to ascertain the performance of competing transport modes (intermodal and road) under different demand scenarios.

Applications of the model to a short-distance transport service show that only price could explain the Freight Forwarder choice for intermodality. The evidence produced by this research suggests that the mode choice process for short-distance transport services may be governed by other decision variables and that current intermodality-oriented policy options should be revised, as they exclude a potential market segment.

1. Introduction

At the European Union (EU) level, intermodal transport[1] has received strong political support over the last two decades (Konings et al., 2008). By 1995 the European Commission (EC) had already recognised the unsustainable growth of road transport and called for a significant modal shift (European Commission, 1995). Later, in 1999, an important advancement was made with the Treaty of Amsterdam, which, for the first time, included sustainability as a key objective in the EU's development paradigm. The EU's first sustainable development strategy (European Commission, 2001a), launched at the 2001 Gothenburg Summit, reinforced the need to limit the growth of road transport and called for a modal shift towards rail or waterborne transport. That same year the EC's 2001 White Paper on Transport proposed a set of measures to attain this objective (European Commission, 2001b). Throughout the decade, other policy documents – including the 2006 Mid-Term Review of the 2001 White Paper

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[1] Intermodal transport is defined as "the movement of goods (in one and the same loading unit or vehicle) by successive modes of transport without handling of the goods themselves when changing modes" (United Nations, 2001).

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on Transport (European Commission, 2006), the 2007 EU's Freight Transport Agenda (European Commission, 2007) or the 2009 EC's Communication on the Future of Transport (European Commission, 2009) – advocated intermodal transport as a means of curbing the unsustainable growth of the transport sector, largely driven by road transport, without jeopardising the economic, social and sustainable development of the EU. Recently, the 2011 White Paper on Transport (European Commission, 2011) underpinned the relevance of intermodal transport for achieving the long-term sustainability of the EU's transport system.

Notwithstanding, at the EU level over 75% of freight (measured in tonne-kilometres) is still transported by road (Cloodt, 2012), intermodal transport accounts for only approximately 5% of total freight (Savy, 2009). The reasons for the difficulties facing intermodal transport are well documented in the literature (Blauwens et al., 2006a; Button, 2010; Frémont and Franc, 2010). Firstly, there is the inherent complexity of producing intermodal transport services (Woxenius, 1998), since it involves streamlining five different types of flows – physical, logical, contractual, financial and relational (Reis, 2010) – between multiple transport agents. Secondly, there are multiple external barriers, including: inadequate regulatory framework (Slack, 2001), absence of an intermodal liability regime (Asariotis, 1999) and lack of integration between the transport networks (Leinbach and Capineri, 2006). These complexities and the barriers contribute to hampering efficiency, raising production costs and reducing market opportunities for intermodal services (Rich et al., 2011). Thirdly, narrow policy options focused on the promotion of medium to long-distance intermodal transport. By way of example, the 2011 White Paper on Transport foresees a modal shift of around 30% from road freight to other modes such as rail or waterborne transport by 2030, but only on distances above 300 km. Captivity by road transport below this threshold is implicitly assumed (European Commission, 2011).

Improving the intermodal transport market positioning requires an increase in competitiveness and the entry into new markets. Considering that, EU wide, around 50% of freight transport demand is for distances up to 400 km (EUROSTAT, 2012), short-distance services may represent an untapped opportunity. Successful cases of short distance intermodal transport reinforce the likely existence of such opportunities (Macharis et al., 2010 or the case presented in this paper).

The promotion of short-distance intermodal transport faces, however, significant challenges. Empirical evidence sets the limits of competitiveness at around 400 km (Tsamboulas, 2008). Also, there is a scarcity of literature on the mode choice behaviour for short-distance intermodal transport. The available literature mainly describes investigations concerning medium to long-distance services (e.g., Janic, 2007 or Tsamboulas et al., 2007) and the EU co-funded research projects primarily use case studies on long distance services and occasionally medium-distance ones.[2] The demonstration that mode choice behaviour is independent of distance is still to be made. Therefore, the validity of deploying the findings to short-distance services is questionable.

The paper presents an investigation aimed at assessing whether mode choice variables used in medium to long-distance transport services can be used to explain agent behaviour in short-distance transport cases. If the hypothesis proves false then we may contend that a gap in the literature concerning the mode choice variables over the short distance may exist. Such a gap may imply that further research is required.

A running intermodal transport service was used as a case study. The performance of the intermodal transport service was compared against a potential road transport service for a set of mode choice variables, including: price, transit time, reliability and flexibility. These variables are consistently reported in the literature as being explanatory for mode choice processes. The performance was assessed using a new micro-simulation model based on agent technology. Agent technology has been successfully applied in the study of transport-related phenomena, since it allows for the customisation of transport agents (e.g., shipper, freight forwarder or carriers) and isolation of their interactions (e.g., physical or information).

This paper is organised as follows. Section 2 briefly reviews the state of the art of transport modelling, agent-based modelling and mode choice. Evidence is given that agent-based modelling can satisfactorily simulate the dynamics of a transport service and that a reduced set of variables is invariably mentioned as key. Section 3 explains the fundamental assumptions and design principles of the simulation model. In Section 4, the case study is described and the simulation model is calibrated. The results of the simulations are analysed in Section 5. Finally, Section 6 summarises the main conclusions of the research and recommends directions for further research in this area.

2. Literature review

2.1. Freight transport modelling

The first European freight transport models date from the early 1970s. Over the years, multiple dedicated freight transport models have been proposed (e.g., Ben-Akiva et al., 2013; Chow et al., 2010; De Jong et al., 2004; Liedtke, 2009; Tavasszy, 2006). It is important to note that the four-step model, initially developed for modelling passenger transport, has been widely and successfully adapted to model freight transport (De Jong et al., 2004). The typical structure of a freight transport model thus consists of four modelling steps: production and attraction of freight, trip distribution, mode choice and trip assignment (Tavasszy et al., 2012). The types of freight transport models developed for each of the four steps are briefly reviewed, and examples provided, in the following.

[2] A search on the EC's TRIP web portal yielded a total of 134 research projects dealing with intermodal topics. No case study or demonstrator was found concerning short distance services (search on: 03rd July 2013).