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Location analysis for the modal shift of palletized building materials

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ABSTRACT

At present, the distribution of palletized building materials is mostly carried out by trucks, despite their movements having negative effects on society, the economy and the environment. However, these problems can be reduced if the transport of palletized goods is shifted to inland waterways. By doing so, the goods are bundled for the main haulage by barge. In order to reduce the transport distances by truck to an absolute minimum, a possible last-mile distribution would have to be organized via a limited number of directly canal-served hubs. The locations of those hubs are crucial for the feasibility of modal shift. This study advances the transport geography literature by elaborating a location analysis model specifically for palletized goods. This model determines the optimal hub location by taking into account the large variation of origins and destinations of transport flows, while the introduction of a cost structure enables potential economic gains (cost savings) and reductions in CO_2 emissions to be calculated. The analysis is performed for transport data on palletized building materials in Belgium. Two concepts were defined, which resulted in an optimal intermodal network of 9 hubs and one with 27 hubs; through the implementation of these networks, respectively 26% and 38% of the transport flows can be shifted to the inland waterways at a profitable cost. It can be expected that over time these percentages will increase further.

1. Introduction

Most transport and mobility movements are performed on the road network (European Commission, 2011). Consequently, they are responsible for several negative externalities, such as congestion, pollution, noise nuisance and accidents. These externalities affect our daily lives, our economy and the environment. Other transport modes – like barge and rail – create similarly negative externalities, but in significantly lower proportions than road transport (CE Delft et al., 2011). As the demand for transport and mobility is expected to continue growing in the coming years and decennia, it is necessary to take into account those other transport modes as reasonable alternatives to the dominant road transport.

For several Western European countries, inland waterways offer many opportunities, as its network is wide and mostly underutilised. In the past, large numbers of merchant transport operated within this network, with all kinds of goods transported by barge to the inner centre of Western European cities. In later ages, this practice disappeared, and canals were closed in many cities. However, following the containerisation of maritime transport that started in the 1970s, inland waterways were rediscovered in the 1990s by shippers, logistics service providers and governments. After big bulk (as traditional first wave) and containers (as second wave) (VUB and COMiSOL, 2006), the challenge now is to find new types of loading units which can be transhipped to the waterway network. Palletized goods constitute one possibility in this regard.

Road transport of palletized goods is currently carried out at a very competitive price, especially when the external costs are not included (Ricci and Black, 2005; Van Dorsser, 2004). However, some initiatives of transporting palletized goods via inland waterways have emerged in recent decades throughout Western Europe. During the early 2000s in the Netherlands, palletized drinks were transported via inland waterways. This Distrivaart project was abandoned in 2004, as the commercial basis was too small (Poppink, 2005). In another project in the Netherlands, the urban distribution of different kind of goods, including palletized goods, is organized by Mokum Mariteam via the local waterway network of Amsterdam. In the region of Paris (France), palletized building materials have been transported by barges since 1987 (Sétra, 2008). In Belgium also, the initial focus was oriented towards the construction sector, as a feasibility analysis (VUB and COMiSOL, 2006) indicated a clear potential for a modal shift of these goods. As a result of this study, different practical experiments were conducted throughout Flanders (Verbeke et al., 2007; VIM, 2012a,b). Currently, transport of palletized building materials on seven fixed routes connecting suppliers and customers that are directly adjacent to canals are being shifted to inland waterways.

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In order to organize the transport of palletized goods by barges in a larger and more (cost-) effective way, a network of transhipment hubs – or regional water-bound distribution centres (RWDCs) – needs to be created within the supply chain. Palletized goods can be bundled onto barges at those hubs, and more sustainable first- and last-mile distribution can be organized. In this way travel distances by trucks can be reduced to an absolute minimum. Previous theoretical studies (Cornillie and Macharis, 2006; Groothedde et al., 2005; Van Dorsser, 2004; VUB and COMiSOL, 2006) and practical experiments (Poppink, 2005; Verbeke et al., 2007, 2012; VIM, 2012a,b) have demonstrated that the length of both pre- and post-haulages has a large impact on the economic feasibility of the modal shift of palletized goods. The hub locations determine the lengths of both pre- and post-haulages: the closer the transhipment hubs are to the important volumes, the lower the number of pre- and post-haulage tonkm that needs to be performed by trucks. As a result, the economic, societal and ecological costs incurred from vehicular travel can be reduced. The need for a substantiated identification of the transhipment locations thus arises. Additionally, both private and public sectors are interested in the economic and ecologic potential of an implementation of the concept.

In order to answer to the above-stated needs, we have developed LAMBTOP (Location Analysis Model for Barge Transport of Pallets). The model is constructed for the Belgian territory (Mommens and Macharis, 2012). This paper is structured as follows: in Section 2, we describe the challenges and principles of a modal shift of palletized goods via a network of RWDCs; the developed methodology is explained in Section 3. The obtained results based on data on palletized building materials transported within Belgium in 2011 are discussed in Section 4. We end with the conclusions.

2. Hub concept

The integration of a main haulage by barge implies that suppliers and/or customers who are not located near an inland waterway need an initial and/or final haulage via road. In those cases, one can talk about intermodal transport.

Still, the supply chain of palletized goods has very different logistical characteristics in comparison with inland waterway transport (IWT) in the form of bulk and containers. Table 1 illustrates these characteristics so as to indicate the challenges that must be dealt with when shifting palletized goods to the inland waterways.

In order to match the characteristics of the palletized goods' supply chains with those of the typical inland waterway transport, well-chosen transhipment hubs must be created within the supply chain. These hubs (or RWDCs) work as regional distribution centres whereby flows of palletized goods are bundled and transhipped to a barge. RWDCs can be supplied via road and inland waterways. Fig. 1 illustrates the possible flows of the supplier's and/or customer's warehouse, depending on the possible directly canal-served facilities:

Table 1
Supply chain characteristics of different cargo types. *Source*: Verbeke et al. (2012).

Supply chain characteristic	Bulk	Containers	Pallets	Typical IWT
Number of SKU (stock keeping unit)	Few	No issue	Many	Few
Volume per SKU	High	No issue	Low	High
Speed of delivery	Low	High	Very high	Very low
Number of drops	Low	Low	High	Very low

1. Directly canal-served supplier's warehouse ⇒ inland waterway ⇒ RWDC ⇒ post-haulage via road ⇒ non-canal-served customer's warehouse.
2. Directly canal-served supplier's warehouse ⇒ inland waterway ⇒ directly canal-served customer's warehouse.
3. Non-canal-served supplier's warehouse ⇒ pre-haulage via road ⇒ RWDC ⇒ inland waterway ⇒ RWDC ⇒ post-haulage via road ⇒ non-canal-served customer's warehouse.
4. Non-canal-served supplier's warehouse ⇒ pre-haulage via road ⇒ RWDC ⇒ inland waterway ⇒ directly canal-served customer's warehouse.

3. LAMBTOP methodology

3.1. Introduction

Since in reality not every supplier or customer of palletized goods has a location near an inland waterway, a network of RWDCs needs to be created (VUB and COMiSOL, 2006). The optimal location of these RWDCs is crucial for all stakeholders, as these locations have a large impact on the profitability of the intermodal transports. Consequently, their locations will also define the potential turnover of the RWDC (Arnold et al., 2001; Aykin, 1995; Kayikci, 2010). The LAMBTOP (Location Analysis Model for Barge Transport Of Pallets) that will be discussed in this paper was developed to determine the optimal location of RWDCs in Belgium. Besides their locations, the model calculates the financial cost of the modal shift and the potential turnover for each distribution centre. This is important information given that transport costs are one of the main determinants in the intermodal decision-making process (Danielis et al., 2005; LOGIQ, 2000; Vannieuwenhuyse et al., 2003). Moreover, the transport price has proved itself as a clear bottleneck in previous studies, not to mention in the Distrivaart project (Poppink, 2005; VIM, 2012a; VUB and COMiSOL, 2006). In addition to the financial outcome, the model also calculates the potential reduction in CO_2 emissions, so as to illustrate the ecological benefit of the modal shift.

We focus on the financial cost structure in Section 3.2 before explaining the used methodology for CO_2 comparison in Section 3.3. The methodology of the LAMBTOP is summarized in Section 3.4. Finally, we focus on the data collection in Section 3.5.

3.2. Cost comparison

The calculation of the financial difference between unimodal road transport and intermodal transport is performed with a cost structure based both on theoretical analyses (Essenciál Supply Chain Architects, 2011; Freight Best Practices, 2005) and practical experiments with palletized building materials (De Munck, 2010; Verbeke et al., 2007; VIM, 2012b). Information regarding these experiments was obtained through contact with several transport experts[1] that accompanied these field tests.

In the first stage, the cost structure only considers direct transport-related costs. In subsequent stages, different scenarios have been added, allowing us to test the sensitivity of the analysis. Firstly, additional depot costs ranging from 1€/ton to 4€/ton have been introduced into the intermodal supply chain. A second scenario takes into account administrative savings accrued through saved transport documents, payment transactions and invoices. The last scenario tests the impact of introducing a general road

[1] The transport experts assist Flemish companies in their search for possibilities to shift (portions of) their transport flows to the inland waterways. The advice and services provided to the transport companies by these transport experts are free of charge, as the experts are appointed by a cooperation of waterway administrators and enterprise unions.