A modal shift of palletized fast moving consumer goods to the inland waterways: a viable solution for the Brussels-Capital Region?

K. Mommens, P. Lebeau & C. Macharis
Vrije Universiteit Brussel, Belgium

Abstract

Intermodal transport offers different advantages in comparison with unimodal road transport. Intermodal transport can reduce the external costs. Additionally, the financial costs of transport can be reduced as well. However, city distribution is nowadays mostly achieved via unimodal road transport, while many cities are located at an inland waterway. Instead of having a large number of trucks and vans entering the city region, goods could be bundled on barges and transported within the city via the inland waterways. They would be then transhipped in urban hub(s) from where a sustainable last-mile distribution could be organized. For bulk and containers, large volumes are already shifted to the inland waterways. Palletized goods are on the contrary just starting to be transported by barges. In order to enlarge those volumes of palletized goods and consequently the economic feasibility of the concept, we analysed the possibility of a modal shift of palletized Fast Moving Consumer Goods (FMCG) for the Brussels-Capital Region. The first step consisted by collecting data on transport flows via interviews: from the initial sample of 62 major enterprises and institutions, 26 accepted an appointment, and 14 amongst them shared their transport data. Over 2.3 million tons (700,000 tons for Brussels Capital Region) of palletized FMCG were captured. The data were analysed in our LAMBTOP model. It determines the optimal hub locations on the bases of the transport flows. Their distribution resulted in 2 predefined hubs. Moreover, the model gives the financial cost of the modal shift and the potential turnover for every hub. Depending on the water-bound locations of origin and/or destination, almost 1.3 million (228,000 for Brussels Capital Region) tons can be shifted cost efficiently.
Keywords: pallets, model shift, location analysis.

WIT Transactions on The Built Environment, Vol 138,
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/UT140301

1 Introduction

Urban goods distribution supports urban lifestyles, serves the economic activities in cities and contributes to their competitiveness (Anderson *et al.* [1]). It is currently mostly achieved via unimodal road transport (STRATEC [2]). The trucks and vans are contributing to increase congestion, pollution, noise nuisance and road accidents. In order to diminish the negative impact of urban transport on health, economy, environment and welfare in general, freight can be shifted towards more sustainable transport modes, like rail and barge (den Boer *et al.* [3]). After all, many European cities are – for historical and economic reasons – well connected to both rail and inland waterway networks. Those networks were used for the urban freight distribution in former times. However, as congestion, pollution and urban liveability are major and rising challenges for cities, more and more urban distribution projects arise, using the available inland waterways. Some successful examples are the 'Beerboat' in Utrecht (NL), 'Vracht door de gracht' in Amsterdam (NL) and 'Franprix' and 'Point P' in Paris (FR) (Sétra [4]).

Those European projects initiated the idea of using the infrastructures available in the Brussels-Capital Region (the canal Charleroi – Brussels – Willebroek) for the urban freight distribution. The focus was narrowed towards palletized Fast Moving Consumer Goods mainly because bulk and containers have already been transferred in large numbers to the inland waterways. The shift from road to barge transport has also started recently for palletized building materials. In order to stimulate these sustainable best practices, the shift of palletized transport could be extended further to other types of goods. However, literature does not seem to have tackled this question. As a result, we analysed the economic feasibility of transferring the palletized Fast Moving Consumer Goods (FMCG) from road to barge transport in the Brussels-Capital Region. Consequently, the research question is divided in three sub-questions;

- What is the optimal number and locations of possible transhipment-hubs?
- What is the economic potential of the modal of palletized fast moving consumer goods?
- Is there a need for supporting policies which initiate the modal shift, and what would be the preferable amount of such subsidy scheme?

To answer above questions, we used the LAMBTOP. This model – which we developed to research the feasibility of a modal shift of palletized goods – determines the optimal transhipment hub locations based on the transport flows and direct transport costs. Additionally, it calculates the cost-efficiency of each origin-destination-combination, as well as the potential turnover volume (in ton) of each transshipment hub (Mommens and Macharis [5]). The methodology of LAMBTOP is addressed in Section 2.1. The required transport flows were collected properly. The used methodology of this data collection is described in Section 2.2, while the data are described in Section 2.3. Subsequently, we discuss the obtained results in Section 3, and give the conclusions in Section 4.

2 Methodology

The presented analysis consists of three stages. Firstly, a desk-research was undertaken in order to identify the most important generators of palletized FMCG in and around the Brussels Capital Region. Those identified generators were contacted in order to get an appointment with them and to collect their required transport flows of palletized fast moving consumer goods. The methodology of those two stages is explained in Section 2.2. The response rate and obtained data are described in Section 2.3.

The collected data are, as third and final stage, analysed with the LAMBTOP, of which the methodology is briefly described in Section 2.1.

2.1 Location- and feasibility analysis

The location- and economic feasibility analysis is performed by the LAMBTOP. This is the acronym for Location Analysis Model for Barge Transport Of Pallets. It is a GIS-model (Geographic Information System), originally constructed for the Belgian territory, but recently enlarged to a European scale. Consequently, different GIS-layers – representing the European inland waterway network and the network of European main roads – are used as first input for the model. The second input is an origin-destination matrix, including the volume for each origin-destination-combination. The model links those origins and destinations to their respective geographical nodes. A cost structure is the third and final input. This cost structure contains transport related costs which are based both on theoretical analyses (Essenciál Supply Chain Architects [6]) and practical experiments with the modal shift of palletized building materials (Verbeke *et al.* [7]; VIM [8]). Information regarding these experiments was obtained through contact with several transport-experts that accompanied these field tests. 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.

The cost structure contains a constant distance and time dependent cost for the unimodal road transport and costs for the loading and unloading of the truck. The intermodal alternative is – in cases with pre- and post-haulages – characterised by a constant distance and time dependent cost for these haulages – which is higher than the unimodal transport cost for reasons of lower average speed and higher average of empty kilometres. Besides this difference in costs, the intermodal alternative has – assuming the same presence of pre- and post-haulages – also to cope with extra costs for loading and unloading the barge, and loading and unloading a truck twice. However, thanks to economies of scale, the barge transport is performed at lower costs than the unimodal road transport. The feasibility of the modal shift comes consequently with a break-even distance, which is defined as the distance at which the costs of intermodal transport equal the costs of unimodal road transport (Rutten [9]).

Future research focusses on the integration of total logistics costs in the LAMBTOP analyses.

The LAMBTOP uses different steps. A detailed description of those steps can be found in Mommens and Macharis [5]. The different steps will be addresses only briefly in this paper.

The model starts with the geographic distribution of all volumes from the origin-destination-matrix. It enables us to detect spatial concentrations or clusters on the one hand. On the other hand, this distribution is used to determine the optimal locations of the transshipment-hubs. The determination of the optimal hub locations is performed in second step of the model. This determination is based on the minimisation of the pre- and post-haulages costs of all volumes. The set of potential transshipment-hub locations is constructed as a continuous selection of points every one kilometre along the inland waterways. The optimal composition of the network of transshipment-hubs is determined by the volume caught by the network and the additional criterion that each optimal transshipment-hub requires an attributed volume of minimum 20,000 ton. This volume corresponds to the yearly volume necessary to justify the implantation of a transshipment-hub for palletized goods (VIM [8]). Predefined locations or already existing transshipment-hubs can be included in the model and its location analysis procedure.

In the third step, the optimal routes are calculated for both the unimodal as the intermodal transport. For this calculation an intermodal network needs to be constructed. The optimal intermodal routes are based on the algorithm of Dijkstra [10], combining the minimisation of the transport time for the pre- and post-haulages and a minimisation of the distance for the transport via barges. The model takes into account the inland waterway classification, as waterways with a CETM-class lower than II (= 600 ton) are excluded. The unimodal routes are calculated via a minimisation of the transport time using the same algorithm of Dijkstra.

Both unimodal and intermodal routes are linked to the cost structure for each origin-destination-combination, and subsequently both obtained costs are compared. Additionally, some realistic scenarios – subsidies to support a modal shift and variations in costs – are used to measure their impact and the sensibility of the analysis.

The LAMBTOP methodology is applied for the collected transport data on palletized transport goods. The methodology of this data collection presented in the next section.

2.2 Selection of freight generators

The research started in January 2013 with the identification of the major generators of palletized fast moving consumer goods in and around the Brussels-Capital Region. Figure 1 shows the geographical zone of investigation: the 19 municipalities of the Brussels Capital Region are included as well as the municipalities depicted in lighter yellow. The zone of investigation that we call “Brussels Metropolitan Region” in this paper is defined as all municipalities located in a range of 30 kilometres from the Port of Brussels. The area is created in order to include the distribution centres of the main retailers which are mostly located in the periphery of the Brussels Capital Region (Strale [11]).

Within the investigated area, the main generators of palletized FMCG were included in the sample based on a desk-research. Different datasets (ADSEI [12]; ATRIUM [13]) regional studies (STRATEC [2]; City of Brussels & Brussels Mobility [14]; Strale [11]; VIL [15]) were collected and linked to each other in order to identify the main generators. The selection of the main generators took also into account the proximity of their distribution centres to the inland waterway. Indeed, intermodal transport becomes more interesting for goods flows that have short pre/post haulage (Groothedde *et al.* [16]). The selection took also into account the diversity of generator types. The sample was required to keep a balanced number of retailers, producers, carriers, institutions, NGO's and hospitals generating flows of palletized FMCG.

The identified sample of generators was then presented to the local authorities responsible for freight transport in the Brussels-Capital Region. With their consultation, a total of 57 major generators were identified. This sample was enlarged to a final sample of 62 generators, as five additional ones were identified during the study as major generators.

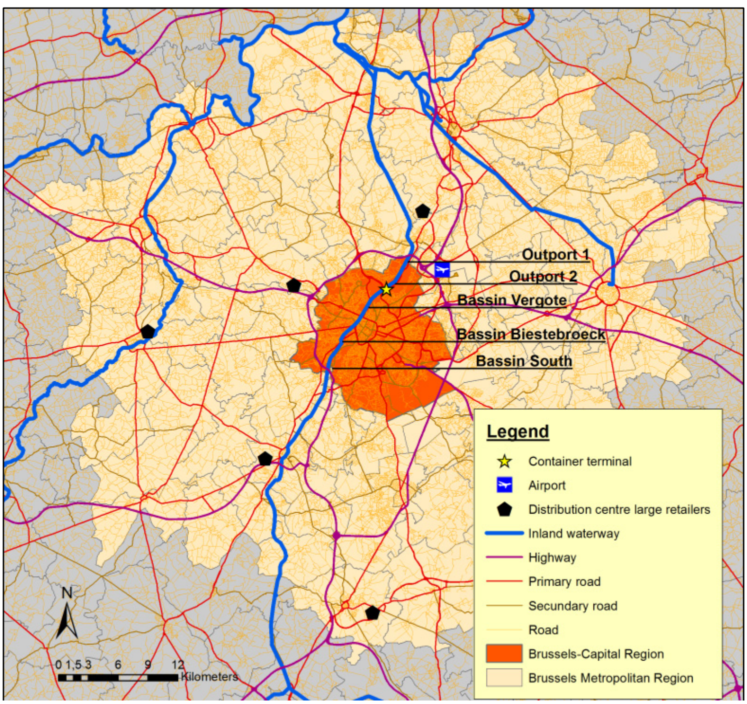


Figure 1: Research area.

2.3 Data collection

All 62 generators were contacted by phone – and/or by mail when needed or requested – in order to get an appointment with them at their (production-/distribution-/sales-) site. Among the 62 generators of the sample, 26 of them showed interest in the investigated logistic concept and accepted an appointment. During these meetings, the generators received a standard questionnaire – with questions related to the company/institution, the transported volumes, their experiences with a modal shift and an origin-destination matrix to be filled in with their transport flows for the year 2012. Fourteen – or 22.6% of the initial sample – answered the questionnaire and the origin-destination matrix. Besides the necessary information gathered through the questionnaires, we were able to ask more insight information.

In total over 2.37 million ton, or 2.90 million pallets were collected via the origin-destination matrices. The sample represents 3.59% of all palletized goods transported on Belgian roads (ADSEI [12]), which is a high number taking into consideration that this research focusses on palletized fast moving consumer goods in the Brussels Metropolitan Region. The different origin-destination matrices were joined in one general matrix. This matrix forms one of the three inputs of the LAMBTOP.

Confidentiality reasons hamper us to give detailed information on the content of those caught pallets, as on the participating enterprises and institutions. This information is however included in the analysis, and presented in this paper in aggregated form. Most of the caught volumes are palletized drinks (61.9%), followed by palletized food (18.3%) and palletized sport commodities (11.4%). More general supermarket commodities (4.1%), packaging materials (2.3%), textile (1.0%) and electronic devices (0.9%), all transport on pallets, are caught in smaller extent. The dominance of drinks and food is not a result of the initial sample composition, but it represents the interest of only a limited number of the major generators in the concept of a modal shift of their palletized fast moving consumer goods. Many of the enterprises and institutions emphasized – during our contacts with them – their constraints which they expect of a modal shift of their goods. Those constraints depend on the sector and the type of goods. First of all the costs, which can be compensated with long transport distances or incentives in favour of a modal shift, like a subsidy or an introduction of a road pricing system. Secondly, some goods require specific conditions, because they are sensible for humidity or for certain temperatures. Extra infrastructures at the transshipment-hubs and at the barge are therefore needed. Those infrastructures come with extra costs. Other goods – like for example palletized electronic devices – require extra security. Again, this comes with additional costs in disadvantage of the modal shift. A third important aspect is that a barge replaces a large number of trucks. Which is positive – for economic, social and ecologic reasons – but it consequently means that a large volume of palletized goods is delivered once instead of spread over a longer period. Space for temporal storage of those goods will be required, which is not easy in an urban setting where space is limited and expensive. The final constraint which we identified during our research is the presence of an already existing and well performing internal organisation of the freight distribution. Many enterprises and institutions are optimising their supply chain to their own key performance indicators. Those are mostly in line with the unimodal road transport as they focus on ‘full truck load’, ‘one-shot-deliveries’, ‘next-day-services’ and ‘just-in-time deliveries’. Shifting (a part) of their palletized fast moving consumer goods to the inland waterways signifies giving in to some of those indicators in exchange for an improvement of their freight distribution in terms of sustainability, reliability and transport-related costs. The LAMBTOP takes only into account those transport-related costs.

3 Results and discussion

The results and discussion can be subdivided into the three sub-research-questions, which are stated in the introduction (Section 1). The first question addresses the optimal number and locations of possible transshipment-hubs. We used
the LAMBTOP based on a proper conducted data collection which identified the largest and favourable situated volumes in and around the Brussels-Capital Region.

In the first step of LAMBTOP, the identified volumes are geographically distributed and presented (Figure 2). The origins are spread all over Europe, while the destinations are concentrated in the Benelux (Belgium-Netherlands-Luxemburg).

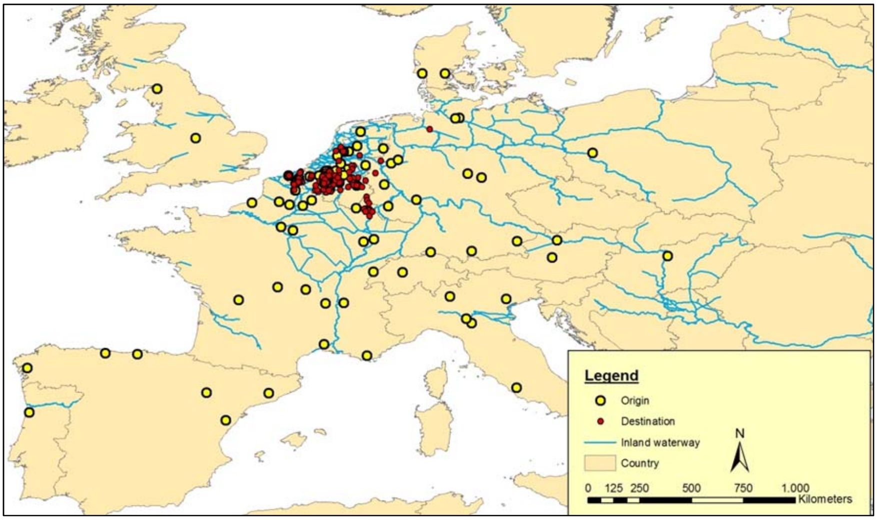


Figure 2: Distribution of the origins and destinations on a European scale.

A focus on the Brussels Metropolitan Region (Figure 3) shows that the destinations are clustered within the Brussels-Capital Region, while the origins are located in the periphery of this region. The origins are moreover distribution centres representing large volumes. The destinations are on the contrary often shops or local distribution centres with relatively small volumes.

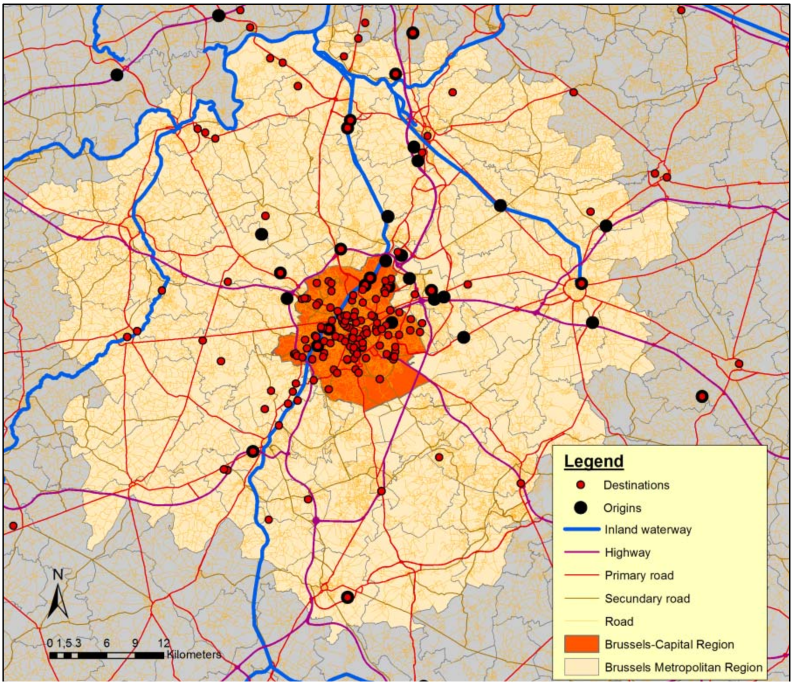


Figure 3: Distribution of the origins and destinations in the Brussels Metropolitan Region.

By performing the next step of the LAMBTOP – namely the location analysis – it enables us to answer the first research-question, which states; 'what is the optimal number and locations of potential transshipment-hubs?' The location analysis is based on the distribution of the volumes. A network of 21 hubs delivers the best results according the methodology. Logically, 21 transshipment-hubs are spread throughout Europe, in a similar pattern as the distribution of the identified volumes. Eleven optimal hub-locations are situated in Belgium, mainly in or near the largest cities. Two hubs are located within the Brussels Capital Region, one at the Bassin Vergote and one at the Bassin Biestebroeck. Both of them are predefined by the Port of Brussels, as they already are planning to build infrastructures for the modal shift of palletized goods at these locations. Our analysis proved however the necessity of at least one transshipment-hub in the Brussels-Capital Region, which justifies the pre-defined ones.

In order the answer to the second research question, the intermodal and unimodal routes are calculated for each good flow, based on an intermodal network of 21 transshipment-hubs. In the case of the intermodal route, the flows are linked to their respective transshipment-hubs. By doing so, potential volumes can be assessed to the transshipment hubs. The results are shown in 5 scenarios. The first scenario assumes that all volumes are shifted to barge transport, irrespective to the costs of unimodal transport. This scenario is called ‘potential’ scenario. The hubs of Leuven (1.2 million pallets), Kortrijk, Liège and Mechelen (each more or less 600,000 pallets) are catching most volumes. When focusing on the transshipment-hubs located in the Brussels Capital Region (Figure 4), it can be noted that the hub of Vergote catches approximately 420,000 pallets, while the hub of Biestebroeck counts more or less 320,000 pallets.

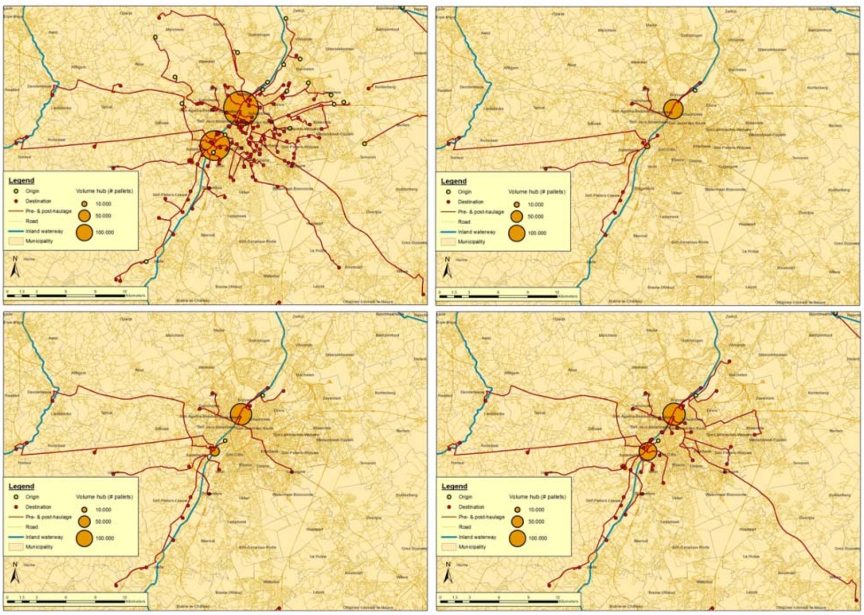


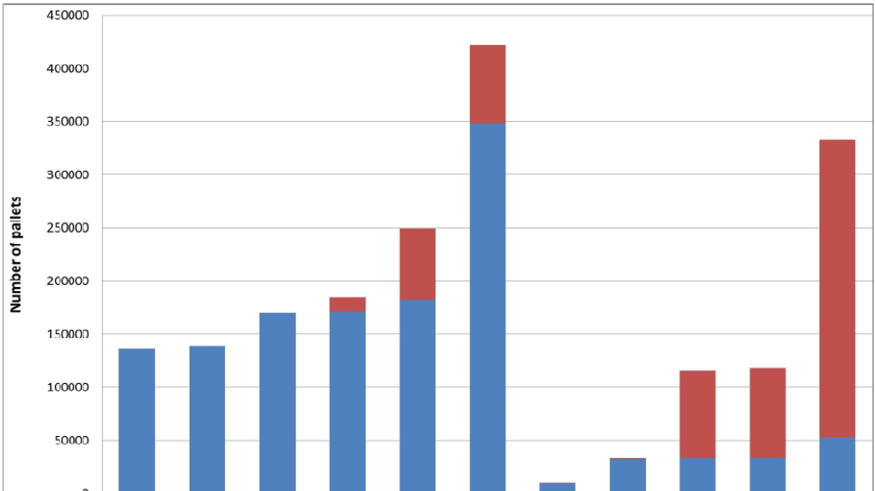
Figure 4: Intermodal routes for ‘potential’ scenario (upper left), ‘cost-efficient’ scenario (upper right), ‘WB_Sub_1’ (lower left) and ‘WB_Sub_2’ (lower right).

The second scenario takes into account the cost-efficiency of the modal shift. Overall, 1.3 million ton of the 2.3 identified ton can be shifted cost efficiently. However, those large volumes are mostly situated on the longer transport distance and moreover; they take into the water-bound location of origin and/or destination. Such water-bound locations prevent additional costs of pre-and/or post-haulage and consequent loading and unloading costs. The volumes assigned to the shops in the Brussels Capital Region are mostly characterized by shorter transport distances. Additionally, water-bound locations are rare in the Capital Region. Therefore the so-called ‘cost efficient’ volumes are rather limited for

www.witpress.com, ISSN 1743-3509 (on-line)

both the transshipment hub of Vergote and Biestebroeck. Figure 4 shows those intermodal routes assigned to both hubs.

In order to answer to the last research-question, we analysed the impact of three subsidy-scenarios; contributing 1€ (‘WB_Sub_1’), 2€ (‘WB_Sub_2’) and 3€ (‘WB_Sub_3’) per shifted pallet. Figure 5 shows that an introduction of 2€/pallet is in benefit of the hub of Biestebroeck, while 3€/pallet enlarges mainly the caught volume of the hub of Vergote.



	Bassin Vergote						Bassin Biestebroeck				
	Profitable	Profitable_WB	WB_Sub_1	WB_Sub_2	WB_Sub_3	Potential	Cost efficient	WB_Sub_1	WB_Sub_2	WB_Sub_3	Potential
Non-urban	0	0	0	13481	67100	72987	368	666	82819	84675	280012
Urban (BCR)	136469	138891	170196	171123	182235	348498	9656	32401	33067	33116	52498

Figure 5: Volumes for the transhipment-hubs located in the Brussels-Capital Region.

However, Figures 4 and 5 illustrate both a major drawback of the obtained results. Intermodal transport is identified as cost-efficient for large volumes of the outer-city. Shifting those transport flows to the inland waterways would imply that long truck haulages in non-urban areas will be replaced by a more sustainable main-haulage by barge, but the hubs located in the city centre would attract additional freight flows in the city. Especially the hub of Biestebroeck has to cope with the problem, as an introduction of subsidies will be beneficial for those non-urban volumes.

Finally, we found that the majority of identified cost-efficient volumes are executed by one respondent. The initial feasibility of the concept will therefore be very dependent of this single actor and – when taking into account the limited number of respondents – a limited number of other enterprises and institutions. A start-up stage should therefore be focused on well identified major generators in order to find the necessary volumes to justify the implantation of the transshipment hubs.

4 Conclusion

This paper presents the economic feasibility analysis of a modal shift of palletized goods in the region of Brussels (Belgium). The research is subdivided into three main questions.

Firstly, we looked for the optimal number and locations of possible transshipment-hubs. In order to answer this question, we identified the major generators of transport flows in and to the Brussels-Capital Region. We contacted them, arranged individual meetings with them and proposed them a standard questionnaire which contained an origin-destination-matrix. Fourteen generators participated to the questionnaire, resulting in over 2.37 million ton, or 2.90 million pallets collected. Based on this caught volume, we used LAMBTOP to determine the optimal number of transshipment-hubs and their optimal locations. The model determined 21 optimal hub. Two of them were proposed by the Port of Brussels, and after justification, included in the location analysis as being predefined.

Secondly, we searched for the economic potential of the modal of palletized fast moving consumer goods. Optimal (unimodal and intermodal) routes were calculated within LAMBTOP, and linked to a cost structure. The subsequent cost analysis indicated a clear potential (1.3 million tons) and economic feasibility of the concept on a European scale.

Lastly, we addressed the need for a subsidy to initiate the modal shift. Three scenarios are built, consisting of an introduction of 1€ per pallet, 2€ per pallet and 3€ per pallet shifted to the inland waterways. Those analyses draw the attention on two aspects. Firstly, the attraction of new urban freight flows to the inner city and secondly the strong dependence of the transport system to a limited number of major generators. The key actors need therefore to be convinced of the importance and potential of the concept.

However, the results need to consider the limitations of LAMBTOP. The model takes only account of the transport-related costs. From the meetings achieved in the data collection phase, several other constraints were identified to be considered for creating a successful modal shift of palletized fast moving consumer goods. Once all constraints are taken into account properly, the modal shift of palletized fast moving consumer goods can be realised successfully.

Acknowledgement

The authors are thankful for the financial support from the Port of Brussels for this research. The Port of Brussels is partner in the European project 'Connecting Citizen Ports 21', where they intend to realise a modal shift of palletized goods.

References

[1] Anderson, S., Allen, J. & Browne, M., Urban logistics – how can it meet policy makers' sustainability objectives? *Journal of Transport Geography*, **13(1)**, pp. 71-81, 2005.

[2] STRATEC, *City Freight – Inter- and –Intra- City Freight Distribution Networks: Work Package 1: Annex report Belgium: Comparative survey on urban freight, logistics and land use palling systems in Europe*, 2002.

[3] den Boer, L.C., Otten, M. & van Essen, H., *STREAM International Freight 2011: Comparison of various transport modes on a EU scale with the STREAM database*, Delft, Netherlands: CE Delft, 2011.

[4] Service d'études techniques des routes et autoroutes (Sétra), Le transport fluvial de palettes à Paris: une activité peu ordinaire' [Barge transport of pallets in Paris: a rare activity], *Revue Transports*, **5**, Paris: Ministère de l'écologie, du développement et de l'aménagement durables, 2008.

[5] Mommens, K. & Macharis, C., Location analysis for the modal shift of palletized building materials, *Journal of Transport Geography*, **34**, pp. 44-53, 2014.

[6] Essenciál Supply Chain Architects, Comparative quantified cost analysis between inland navigation and road transport, for palletised goods, *N554/2010 – Belgium. Preliminary study for Waterwegen en Zeekanaal NV and NV De Scheepvaart*, 2011.

[7] Verbeke, F., Cornillie, I. & Macharis, C., De derde golf in de binnenvaart: palletvervoer succesvol getest in de praktijk' [The third wave in barge-transport: pallettransport successfully tested in practice], *Vervoerslogistieke Werkdagen 2007*, Grobbendonk, Belgium: Nautilus Academic Books, pp. 376-389, 2007.

[8] Vlaams Instituut voor Mobiliteit (VIM), *Eindrapport Modelproject en Distributieanalyse Build over Water* [Final report of the project and distribution-analysis Build Over Water], Project nr. P029, Diepenbeek, 2012.

[9] Rutten, B.J.C.M., The design of a terminal network for intermodal transport, *Transport Logistics,* **1(4)**, pp. 279-298, 1998.

[10] Dijkstra, E.W., A note on two problems in connexion with graphs, *Numerische Mathematik 1*, pp. 269-271, 1959.

[11] Strale, M, *Rapport d'activité de 18 mois de recherches: La Logistique comme outil de reconversion des ports urbains: application au port de Bruxelles* [Rapport of 18 months of research: Logistics as reconversion tool in urban ports: application for the Port of Brussels], Prospective Research For Brussels, 2011.

[12] Algemene Directie Statistiek en Economische informatie (ADSEI) [General Agency of Statistics and Economic Information], Belgium Federal Government, FOD Economie, KMO, Middenstand en Energie, Brussels [FOD Economy, SME, Private sector and Energy], 2010.

[13] ATRIUM, *Profiel en consumptiegewoonten van de Brusselse klant* [Profile and consumption habits of consumers in Brussels], 2007.

[14] City of Brussels & Brussels Mobility, *Gemeentelijk Mobiliteitsplan van de Stad Brussel: Fase 1: plaatsbeschrijving, diagnose en precisering van de doelstellingen: Deel 1 aanpak op maat van de stad* [Municipal mobility plan of the City of Brussels: Phase 1: Description of the location,

www.witpress.com, ISSN 1743-3509 (on-line)

diagnosis and clarification of the goals: Part 1 approach tailored for the city], 2010.

[15] Vlaams Instituut voor Logistiek (VIL), *Logistieke Poort Vlaams-Brabant: Fase 1; De inventaris van de logistieke sector* [Logistic gate Flemish Brabant: Phase 1; inventory of the logistics sector], 2008.

[16] Groothedde, B., Ruijgrok, C. & Tavasszy, L., Towards collaborative, intermodal hub networks. A case study in the fast moving consumer goods market. *Transport Research Part E*, **41**, pp. 567-583, 2005.