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A matching model for the backhaul problem ☆

Erhan Demirel *, Jos van Ommeren, Piet Rietveld

Vrije Universiteit, Department of Spatial Economics, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands

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ABSTRACT

The 'backhaul problem' is characterized by an imbalance in transport flows between locations. In a perfectly competitive framework with perfect information, the price of transport from low demand locations to high demand locations, the so-called backhaul price, drops to zero when the imbalance is sufficiently large. However, this result is inconsistent with empirical observations for many competitive transport markets (e.g. taxi and inland navigation markets). In this paper, we develop a matching model to show that a deviation from perfect information may address this inconsistency. We argue that carriers' search time to locate customers plays an important role in the determination of prices. We demonstrate that carriers are compensated for a part of the transport cost and for the time they search for customers. This implies positive backhaul prices. The matching model is numerically applied to the inland navigation shipping market in the Rhine river area in Western-Europe. We find that backhaul prices are substantial.

1. Introduction

Freight prices play a fundamental role in trade and therefore determine regional and international transport activities (see, e.g., Krugman, 1991). Hence, a deeper understanding of freight prices is important for our understanding of freight transport. A fundamental issue is then whether freight prices have a one-to-one relationship with costs or that freight prices are endogenous with respect to transport demand. In an increasing number of theoretical models, the importance of this issue has been recognised. For example, Anderson and van Wincoop (2004) stress the need to deal with this issue in studies on trade.

There are a number of reasons why freight prices may be endogenous with respect to transport activity. Transport markets may be oligopolistic or density economies may arise (e.g., Behrens et al., 2006, 2009). Another reason as already discussed 100 years ago (Pigou, 1913) is that a large share of the transport costs are *joint* (because carriers return to the location of origin) whereas the demand for transport is direction specific, which is frequently referred to as *the backhaul problem.*

The 'backhaul problem' is a well-known phenomenon in transport economics, both in freight and passenger transport studies. It refers to the situation where the volume of transported goods or persons is not in balance between two (or more) locations, which means that transport flows are mainly in one (or more) dominant direction(s). Carriers may then be faced with the difficulty of finding freight or passengers (backhaul) for their return trip. The importance of the backhaul problem was also noted by Samuelson (1954) in his seminal paper in which iceberg transport costs were introduced: "Realistically,

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* Corresponding author. Tel.: +31 205982936.
E-mail addresses: edemirel@feweb.vu.nl (E. Demirel), jommeren@feweb.vu.nl (J.van Ommeren), prietveld@feweb.vu.nl (P. Rietveld).

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...there are joint costs of a round trip, so [the transport costs for east and west transport] will tend to move in opposite directions, depending upon the strengths of demands for east and west transport".

Imbalance in freight transport flows is extremely common (see e.g. Wilson, 1987). In the current study we aim to study the effect of imbalance on price formation, so one must know the degree of imbalance at the level of the individual carrier, which is difficult to observe. The imbalance at a more aggregate level has been extensively studied however. In particular, the imbalance in flows at the national level using annual observations has been studied by a large number of studies in the trade economics literature and has been shown to be substantial (see e.g. Lee et al., 2006). Most likely, the imbalance is much more pronounced for transport flows between smaller regions and shorter periods of observation (due to time-variation in demand). At the level of carriers, imbalance may even be more pronounced, because carriers are frequently specialised in a certain type of freight which generates additional imbalance. For example, transport carriers which are specialised in the transport of edible oils are generally not allowed to transport other kinds of (nonedible) freight.[1] Imbalance in a context with location shift of firms and agglomeration, and endogenous freight prices is studied by Behrens et al. (2009). However no distinction is made between fronthaul and backhaul prices.

Theoretical contributions to the backhaul literature typically assume imperfect competition in the transport market or the presence of regional agglomeration. For example, the study by Rietveld and Roson (2002) assumes a transport monopolist, whereas Behrens et al. (2006) assumes a limited number of transport suppliers. Behrens and Picard (2008) as well as Behrens et al. (2009) assume the presence of regional agglomeration. These models have two important characteristics in common: they do not apply to the case of perfect competition and they assume perfect information about supply and demand. In contrast, we are particular interested in competitive transport markets because in many countries, the truck as well as the inland shipping market are characterized by a high level of competition. In these markets there are a large number of suppliers so that the market power due to the size of the supplier can be assumed away. In these markets, there is also free entry and low capital costs which enhances competition. For example in the inland navigation market in Western-Europe thousands of carriers are active, of which most are sole-proprietorships.

To understand these markets, it is common to rely on the standard competitive model that is used in textbooks (see Boyer (1998), but also Felton (1981). This model is indeed useful to explain behavior for these transport markets, but a major restriction of the analysis of the standard competitive model is that it is assumed that information about demand and supply is perfect, which we believe is a restrictive assumption and which also generates the prediction that given imbalance in transport flows, backhaul prices are zero, because of excess supply in the low demand region, which is inconsistent with empirical observation, as will be explained in detail in the next section.

Our study on backhaul pricing is not only relevant to increase our understanding of freight markets, it also sheds light on policy questions, such as how to share the burden of infrastructure improvement in a transnational context. A common practice is that each country pays for the infrastructure costs on its own territory. However, in the case of backhaul problems the benefits of the improvement are distributed in a rather uneven way: one country will receive a much larger share of the benefits than the other one. Knowledge on how the benefits are spread between the two locations (countries) may help to arrive at a proper division of infrastructure costs. A case with high political relevance concerns the distribution of costs between Belgium and The Netherlands on sharing the costs of dredging in the West Schelde river, which is located in Dutch territory, but where the Belgian port of Antwerp is the main beneficiary. In this case it has been decided that Belgium will pay for the dredging, even though the river is situated on Dutch territory. Similar discussions, but more implicit, take place between other pairs of countries along the Rhine or Danube, where water management costs to improve the navigability have to be shared between countries and where benefits are unevenly spread due to the backhaul problem.

In the current paper, in Section 2 we discuss backhaul issues assuming a competitive market with perfect information, as is standard in textbooks, and we emphasize the importance of introducing imperfect information. We introduce in Section 3 a two-location transport framework which incorporates a matching model to study the backhaul problem. In Section 4 we analyse the backhaul problem numerically, with input values chosen from the inland navigation market on the Rhine river in Western-Europe. In particular, we investigate the effect of (anticipated) changes in transport cost on freight prices, in the context of imbalance. An increase in transport cost may for example be anticipated in Europe due to climate change, as low water levels will decrease the speed of freight transport (see Jonkeren et al., 2007). Section 5 concludes.

2. Relationship with the literature

To understand the issues relevant to the backhaul literature, it is sufficient to focus on transport between two locations (one location with a high demand for transport and one with a low demand). Theories based on perfect competition with perfect information predict that above a minimum degree of imbalance in demand, the quantity transported from location L, with low demand for transport, is less than location H, with high demand for transport, and the price for transport from the low demand location to the high demand location, the so-called backhaul price, will drop to zero.[2] The latter result is intuitive because carriers are indifferent between returning with or without backhaul. This means that the cost of transport from one

[1] At first sight it may seem that in the passenger market the backhaul problem is absent, as nearly all passengers return to their location of origin. However, there is a large time variation in demand which induces low load factors and therefore a backhaul problem in the public transport as well as in the taxi market.

[2] This result is the classical result as featured in transport economics textbooks such as Boyer (1998).