Journal of International Economics 85 (2011) 280–291

Contents lists available at ScienceDirect

Journal of International Economics

journal homepage: www.elsevier.com/locate/jie

Transportation, freight rates, and economic geography

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ARTICLE INFO

Article history:
Received 3 December 2009
Received in revised form 15 June 2011
Accepted 16 June 2011
Available online 23 June 2011

JEL classification:
F12
R12

Keywords:
Competitive transport markets
Freight rates
Trade
Economic geography

ABSTRACT

We investigate the role of competitive transport markets in shaping the location of economic activity and the pattern of trade. In our model, carriers supply transport services for shipping manufactured goods, and freight rates are set to clear transport markets. Each carrier must commit to the maximum capacity for a round-trip and thus faces a logistics problem as there are opportunity costs of returning empty. These costs increase the freight rates charged to firms located in regions that are net exporters of manufactured goods. Since demand for transport services depends on the spatial distribution of economic activity, the concentration of production in one region raises freight rates to serve foreign markets from there, thus working against specialization and the agglomeration of firms. Consequently, a more even spatial distribution of firms and production prevails at equilibrium when freight rates are endogenously determined than when they are assumed to be exogenous as in the literature.

1. Introduction

Factor mobility and transport costs are the two key ingredients that set apart the New Economic Geography (NEG) from more traditional trade theory. While the implications of factor mobility for trade and the spatial structure of the economy have been analyzed in depth, transport costs have been a more neglected topic. Most of the recent *theoretical* research in New Trade Theory (NTT) and NEG indeed heavily relies on restrictive assumptions about transportation: transport costs are assumed to be incurred in the goods shipped ('iceberg'), they are symmetric irrespective of the shipping direction, and they are independent of the spatial organization of the economy.[1] The most restrictive assumption is, however, that transport costs for goods are treated as being *exogenous parameters* and not prices set by the interplay of supply and demand. Although this parametric treatment is a good starting point that has allowed to break new ground in the rigorous formalization of 'old stories' about trade patterns and agglomeration in the presence of spatial frictions, it leaves a good deal of those stories unexplained. How are transport costs set by the market? How do they react to changes in supply and demand? And how do changes in supply and demand ultimately feedback on transport costs, trade patterns, and the location of industry?

The study of these questions is not merely an academic exercise. Consider, for example, the growing imbalance in manufacture trade between China and the U.S., which has become an issue for the transport sector as it creates important logistics problems associated with the 'empties'. About 60% of the containers shipped from Asia to North America in 2005 came back empty, and those "that did come back full were often transported at a steep discount for lack of demand […] shipping companies charge an average of $1400 to transport a 20-foot container from China to the United States. From the United States to China, companies charge much less: $400 or $500". A similar picture emerges for air freight as "airlines had become so eager to put something in their cargo holds on the inbound journey to China that rates go as low as 30 to 40 cents a kilogram, compared with $3 to $3.50 a kilogram leaving China".[2]

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[1] See, e.g., Krugman (1980), Helpman and Krugman (1985), Krugman (1991), Fujita et al. (1999), Ottaviano et al. (2002), Fujita and Thisse (2002), and Baldwin et al. (2003).

[2] The various figures and quotes are taken from the International Herald Tribune, Online Edition (by T. Fuller, January 30, 2006; http://www.iht.com/articles/2006/01/29/business/ships.php?page=1); and from http://www.logisticstoday.com/displayStory.asp?sNO=8200. Further evidence is provided by the *Review of Maritime Transport* (2007, Table 37), which reports the following ratios for container freight rates: 737$/1643$ between the U.S. and Asia; 755$/1549$ between Europe and Asia; and 1032$/1692$ between the U.S. and Europe (all values expressed in U.S. dollars per twenty foot equivalent units, TEU).

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doi:10.1016/j.jinteco.2011.06.003

The foregoing figures strongly suggest that the growing imbalance in China–U.S. merchandise trade is increasingly reflected in transpacific freight rates and that those rates are becoming increasingly asymmetric. The key objective of this paper is to formalize these ideas by endogenizing transport costs through a market mechanism in a model of trade and geography. In our setting, competitive carriers supply transport services for shipping manufactures across regions, and *freight rates* – the prices for transport services – are determined to clear transport markets. Carriers must commit to the maximum transport capacity required for a round-trip and, therefore, face a logistics problem: there is an opportunity cost associated with returning empty ('backhaul problem'), and that opportunity cost depends on the shipping direction. For instance, when a container ship returns partly empty to its harbor of origin, that ship has a very low opportunity cost of transporting additional goods in that direction. Carriers are then enticed to undercut the price set by any fully loaded ship so that there is downward pressure on freight rates in the direction of excess supply of transport services. By symmetry, there is upward pressure on freight rates in the opposite direction.

This simple market mechanism has two consequences. First, freight rate asymmetries widen with increasing imbalances in trade flows, as observed in reality. Second, since imbalances in trade flows are closely linked to the spatial clustering of economic activity, freight rates tend to increase in economic core regions (that produce a lot of manufactures), thus creating a cost wedge for shipping across different markets. Many models of trade and geography show that firms have incentives to save on either production costs or transport costs by locating in markets with either lower wages or larger demand. Yet, the foregoing cost-savings argument must be qualified in the presence of endogenous freight rates since the region specializing in manufacturing – being a net exporter of manufactures – also tends to have higher freight rates. The latter reduce firms' incentives to locate in that region by raising 'delivered' production costs, thereby working against specialization and the clustering of economic activity.

To formally explore the links between trade, geography, and freight rate asymmetries, we incorporate a competitive transport sector into the model developed by Ottaviano et al. (2002). That model allows us to deal with both trade ('footloose capital model') and geography ('core–periphery model') in a simple way. Carriers supply a homogeneous transport service under constant returns, which manufacturing firms use to ship their output across regions. Transport costs are assumed to be linear, which fits with the empirical findings by Hummels and Skiba (2004) who reject add-valorem transport costs of the iceberg-type. Our assumption of competitive transport markets is mostly relevant for high density routes that are also the routes where trade imbalances are larger (e.g., China–U.S.–Europe). It may be less relevant for low density peripheral routes that are monopolized by a few carriers with inferior shipping technologies, higher freight rates, and stronger price discrimination across cargo types.[3] Although the assumption of perfect competition in the transport sector simplifies the analysis, it is not essential to our qualitative results. Indeed, the basic logistics problem created by trade imbalances between locations also arises in transport markets characterized by imperfectly competitive structures. As a case in point, a monopolistic carrier would also set higher freight rates for goods originating from locations that have larger outbound export volumes.

Previewing our key results, we first show that the existence of a competitive transport sector significantly dampens the so-called Home Market Effect (HME) that is typically emphasized in the NTT and NEG literatures. In particular, when the physical cost of transporting goods becomes sufficiently small in the footloose capital (FC) model, exogenous freight rates lead to full agglomeration of firms in the larger region, whereas endogenous freight rates yield dispersion of firms with no home market bias. Endogenous freight rates respond to trade imbalances and thus reduce the extent of specialization and clustering of economic activity. This result continues to hold when (i) transportation includes exogenous loading/handling costs that are not affected by the backhaul problem, and (ii) in a more complex version of the model where all goods incur trade costs. Second, we show that in the core–periphery (CP) model, endogenous freight rates lead to multiple and different types of stable spatial equilibria. In particular, whereas only full agglomeration is a stable equilibrium under exogenous freight rates when the physical cost of transporting goods is low, both full agglomeration and full dispersion may simultaneously be stable equilibria under endogenous freight rates.

The remainder of the paper is organized as follows. Section 2 selectively surveys the related literature. Section 3 develops the basic model and describes the structure of the transport sector. Section 4 investigates the footloose capital model and shows that endogenous freight rates are a strong dispersion force. We provide several robustness checks and show that our qualitative results hold true even when we relax various critical assumptions. Section 5 then extends the discussion to the core–periphery model and characterizes the spatial equilibria. Finally, Section 6 concludes.

All proofs and appendix material are provided in a supplementary file, available online from the journal website.

2. Related literature

The presence of trade costs in classical trade theory can be traced back at least to Samuelson (1954) and Mundell (1957). These authors discussed the role of transportation in trade under the convenient assumption of 'iceberg costs', i.e., costs that are directly incurred in terms of the goods shipped across locales. This modeling strategy turned out to be so convenient – allowing for trade frictions while obviating the need for a separate transport sector – that it has been widely followed in most of classical trade theory, NTT, and NEG. Consequently, the theoretical literature in those fields has, in general, devoted rather little attention to the modeling of a separate transport sector. However, several early trade theorists have considered that sector in more detail. Falvey (1976), Cassing (1978a), and Casas and Choi (1985), among others, all model a separate transport sector in full-fledged general equilibrium Heckscher–Ohlin–Samuelson models. Their key objectives are to investigate how the presence of that sector affects relative prices across countries, alters trade volumes and modifies the potential gains from trade. See Casas (1983) and Botazzi and Ottaviano (1996) for overviews of these results.

The NTT and NEG literatures have also devoted some attention to the explicit modeling of transport costs and their impacts on trade flows, the distribution of economic activity, and regional specialization. Takahashi (2006) discusses the consequences of both government spending on infrastructure and the choice of transport technology on the agglomeration process. Behrens and Gaigné (2006) and Behrens et al. (2006) endogenize transport costs by assuming the presence of transport density externalities. Although these contributions enrich the modeling of transport costs, they do not really incorporate a transport sector. There are but a few contributions that consider explicitly such a sector in the presence

[3] The empirical findings seem mixed. Whereas Clyde and Reitzes (1995) find no relationship between freight rates and carriers' market concentration on shipping routes, Hummels et al. (2009) find that freight markups are slightly increasing with market concentration (Skiba, 2007, finds that freight rates fall with overall trade volumes). Francois and Wooton (2001) argue that ocean shipping is organized by shipping conferences that are suspected to sustain collusion. Yet, Stopford (2009) finds that the concentration of ownership is rather low in the container liner fleet as compared to other industries, and Sjostrom (1989) finds no significantly higher markups. Larger markups are, however, found for the air transportation sector (e.g., Micco and Serebrisky, 2006).