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ORIGINAL ARTICLE

Measuring concentration in transhipment markets: methodologies and application to a European case

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Abstract

This paper develops heuristic approaches to define the market and measure concentration in the inland transhipment market where different terminal operators compete. These approaches can be used by policymakers to implement more effective policies that could lead to an increase in the market share of intermodal freight transport (IFT). The first approach segments the market using a transport cost analysis. The second approach uses the total trade and the aggregate throughput of the terminals in each IFT demand area. The similarity in results validates the two approaches, suggesting that they can both be used in situations of limited data availability. Applying these approaches to the IFT network of the European Union, we find that inland transhipment markets in the EU are oligopolistic in structure and thus highly concentrated. In general, the north of the EU shows less concentration compared with the central and southern regions of Europe. According to the second approach, transhipment markets have a slightly higher degree of concentration compared with the first approach. Such concentration needs more attention from policymakers so as to develop policies to increase competition and to make economic policies more effective.

Keywords Transhipment markets · Competition policy · Inland terminals · Intermodal freight transport · Transport market analysis · Market concentration · Transport policy

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1 Introduction

Intermodal freight transport (IFT) is defined as "unitized freight transport by at least two transport modes" (EU Commission 2001). In a typical IFT service, at least one transhipment (or terminal operation) takes place between two or more transport modes. The main haulage is mostly carried by train or barge, while truck is used for the initial and final legs of the goods movement (pre and post haulage). During the transportation, terminal or inland transhipment are key components of IFT, as they are the interface between the different transport modes.

The use of intermodal transport solutions involving rail and inland waterways is believed to provide an attractive alternative to single-mode road transport (Kim and Van Wee 2011). In this regard, the European Commission has initiated many research programs to stimulate intermodal transport. Yet, the market share of IFT has not grown significantly (Behdani et al. 2020). The European Commission has also paid growing attention to trans-European intermodal freight transport networks, in terms of competition and market structure. According to the EU Common Transport Policy, transport markets should be liberalized to the maximal extent (Reggiani et al. 2000). Therefore, increasing competition is one of the main topics in the EU transport policy agenda (Zografos et al. 2012). Market analysis is also important for policymaking because the characteristics of the market can influence the responses of market players (e.g., terminal operators) to different economic policies. For example, the effectiveness of policies regarding sustainability and fuel taxes can be influenced by market characteristics, e.g., market structure and concentration (Mandell et al. 2014).

The transport market includes different submarkets, e.g., pre/post haulage, main haulage, and transhipment. The inland transhipment market is a market where different terminals compete with each other for the transhipment service to different shippers, carriers, or freight forwarders. Different policies have been applied at EU and national levels to increase competition in the pre/post haulage and main haulage submarkets, but less attention has been paid to the transhipment submarkets. For example, Zografos et al. (2012) mention that, in most EU countries, only a small part of public funds is allocated to develop inland terminals, while substantial funding is allocated to improve connecting infrastructure. Similarly, policy focus has been primarily on the transportation segments of the chain (i.e., pre/post and main haulage), using tools such as monetary aids, taxes, public–private partnerships, or infrastructure pricing (Hesse 2004; Zografos et al. 2012; Visser and van Binsbergen 1999; Mandell et al. 2014; Ogden 1992). Indeed, a prerequisite for designing effective policies is a detailed analysis of market structure.

However, the scientific literature on IFT market analysis is limited to a few studies (Wiegmans et al. 1999; Makitalo 2010; Sys 2009; Saeedi et al. 2017b; Saeedi et al. 2017a; Bruce et al. 2018). In Saeedi et al. (2017a), we have presented the intermodal freight transport market structure (IFTMS) model to conduct a network-based study of the IFT market. Here, various actors (i.e., pre/post haulage operators, terminals, rail/barge operators, transport chains, and corridors)

are competing at different levels within distinct markets (i.e., pre/post haulage, transshipment, main haulage, corridor submarkets, and O–D pairs) to deliver an integrated IFT service. Then, in Saeedi et al. (2017b), we developed a methodology in which a model-based approach is used to define the geographic boundaries of the transhipment submarkets and provide detailed and consistent data for market analysis.

This calls for methods and tools to measure the market concentration of transhipment submarkets. We discuss two methods for this purpose which are also applied to a case of the European IFT market. We compare them in terms of preciseness, usefulness, and required data. The methods can be used by researchers and policymakers to analyze the market structure of transhipment submarkets. Additionally, they can be a basis for analyzing the impact of policies on the market before and after policy implementation. The rest of the paper is structured as follows: Section 2 is a literature review, the methodology is presented in Sect. 3, in 4 we apply the methodology to the European transhipment markets, and finally, Sect. 5 presents our findings and policy recommendations.

2 Theoretical background

In this section, we review the theoretical background of freight transport market analysis. First, the IFT market is defined. Subsequently, we present the literature on qualitative analysis of the IFT market, and we review the quantitative measures used to analyze the IFT markets.

2.1 Definition of intermodal freight transport market

Within the IFT market, actors (i.e., pre/post haulage operators, terminals, rail/barge operators, transport chains, and corridors) compete at different levels within distinct submarkets to offer an integrated IFT service. Different players are active in different stages/tiers of an IFT chain. For example, different truck operators compete in the pre/post haulage market, different terminals compete in transhipment activities, and different barge/rail operators compete in the main haulage segment of an IFT chain (Fig. 1).

In the literature, the term relevant market describes the physical place where competition takes place and the consumers and suppliers of a specific good or service interact (Sys 2009; Haralambides 2019). In other words, the market area includes all players providing a similar product or service and located in proximity to the demand points (for that product/service). Accordingly, the market is an area where a set of suppliers and demanders interact to determine the price of a good or service (Garten et al. 1985). Taking into account this definition, the transhipment market is a geographical area in which different terminal operators are competing to capture the transhipment container and to offer transhipment services to different shippers, carriers, or transport intermediaries.

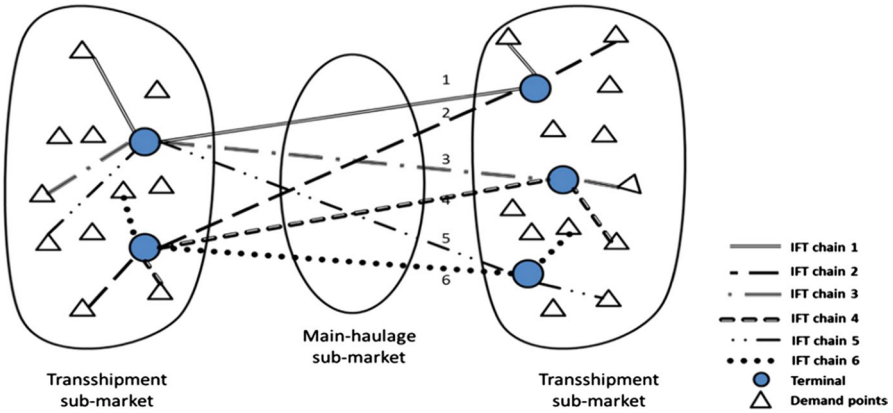

Fig. 1 Spatial distribution of different submarkets inside a corridor of an IFT network. *Source* Adapted from Janic (2007)

The determination of the IFT market is complicated because it depends on many factors, e.g., costs (for road transport, rail/barge transport, and transhipment), transport distances, freight volume, location of inland terminals, and frequency (Limbourg and Jourquin 2010).

Niérat (1997) has compared road and rail-truck intermodal transport, applying spatial theories to define the market of rail terminals and to define the zones for which each mode is the most competitive. According to this author's spatial analysis, the terminal market is part of a family of Descartes's ovals. Kim and Van Wee (2011) used a simulation model to find the (relative) importance of the various factors influencing the IFT break-even distance. The authors have considered the terminal market either as a circle or an ellipse.

In the case of the port market, Wan et al. (2020) have applied the membership degree method and the Huff model to the hinterlands of China's 20 major foreign trade container ports, aiming at a clear understanding of the characteristics of shared hinterlands, and port market areas with regard to "capturing" the transhipment container.

Analyzing the IFT market can be challenging due to this multistage characteristic of IFT services. Different levels of analysis can thus be conducted. Most of the works mentioned previously have done such segmental analysis in which the market concentration of different submarkets (e.g., the transhipment submarket) is measured. One can also analyze the IFT market from a chain perspective, where competition between different IFT chains within a corridor is studied. At the same time, multiple corridors are potentially competing for cargo transportation between an origin and a destination. The IFTMS model presented in Saeedi et al., (2017a) helps to conduct such a multilevel market analysis.

IFTMS uses graph theory to define these submarkets in an IFT network (Fig. 2). The submarkets are represented as nodes (transshipments), links (main haulages), and paths (corridors, and O–Ds) in the model. Each "corridor"

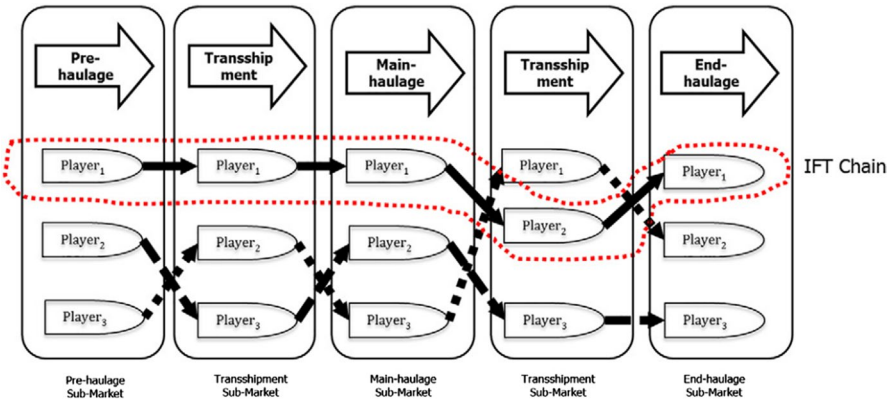

Fig. 2 Different players inside a corridor of an IFT network. S*ource*: Authors own illustration

includes different IFT chains—sequences of nodes and links from an origin to a destination—which are organized by different forwarders.

As the submarkets inside an IFT network are defined, IFTMS assigns the flow to the IFT network corridors, and respective chains, links, and nodes by applying a flow optimization model. Next, the concentration indexes for these IFT submarkets are calculated.

Saeedi et al. (2017b) has developed a method to define the geographic boundaries of the transhipment submarkets and provide detailed and consistent data for market analysis. In that paper, using the concepts of transport cost and IFT break-even distance, the authors define the transhipment submarket as a circular area with a certain radius around the regions in which there is a demand for terminal services.

2.2 The IFT market: qualitative analysis

There are different contributions dedicated to the qualitative analysis of the IFT market and its submarkets. Using Porter's competitive forces model, Wiegmans et al. (1999) have analyzed the stakeholders of the terminal market (i.e., industry competitors, buyers of terminal services, and the suppliers of the terminal infrastructure). Potential entrants into the terminal market; the substitutes for the use of freight terminals; and the terminal environment (that includes transport infrastructure, load units, transport means, transport networks, environmental issues, and regulation) are mentioned as the competitive forces included in their framework. Wiegmans et al. (1999), however, did not present any quantitative analysis to measure industry concentration. In another qualitative analysis of IFT markets. Makitalo (2010) investigated the Finnish railways market using Delphi techniques and illustrated the biggest market entry barriers. These were rolling stock acquisition, access to the services, administrative factors, and recruitment of skilled personnel.

Many papers have analyzed the liner shipping market, e.g., Agman (1976), Davies (1986), Davies (1989), Franck and Bunel (1991), Kent and Ashar (2001), and Haralambides (2007). Lam et al. (2007) have used the

structure–conduct–performance (SCP) framework to analyze liner shipping dynamics in the transpacific, Europe–Far East and transatlantic trade routes. Bruce et al. (2018) have measured the degree of competition in container shipping by calculating an indicator of concentration and an indicator of market share instability. Haralambides (2007) has focused on the type of models in liner shipping concerned with market structure, looking at the degree of capital concentration, carrier coalitions, such as conferences and alliances, monopoly power, and related pricing strategies. None of these works, however, has looked at the market structure of inland transhipment submarkets and analyzed it quantitatively.

2.3 Measuring IFT market concentration

The main determinant of market structure is market concentration. Market concentration refers to the number and size of production firms. Concentration is typically measured using data on the market share of industry firms (i.e., throughput of opertors) (Lipczynski et al. 2017). There are many indexes to measure the degree of concentration in the market. The most frequently used ones are the concentration ratio (CR) and the Herfindahl–Hirschman Index (HHI) (US Department of Justice and the Federal Trade Commission 2010). In freight transport literature, there are several studies aimed at measuring the concentration of different freight transport markets. For example, Merikas et al. (2013) investigate changes in the structure of the tanker shipping market—using the CR index and the HHI index—and its impact on freight rates. The authors find that market concentration has increased since 1993 in this sector. Sys (2009) studied whether the liner shipping industry, as a unimodal freight transport system, is an oligopolistic market. To answer this question, she analyzed market structure using concentration indexes. Her findings show that the containerized shipping industry has experienced increasing concentration, and the trade lanes are in either loose oligopoly or tight oligopoly markets. Saeedi et al. (2017b) have measured market concentration in transhipment markets, in parts of the European IFT network. They find that the majority of transhipment markets are highly concentrated.

3 Methodology to analyze transhipment markets

In this section, two approaches for defining transhipment markets and analyzing their market structures are presented. Figure 3 shows the steps of these two approaches. These steps are explained below.

3.1 Defining relevant transhipment markets and identifying market players

There are two main methods for defining the relevant transhipment market in the literature: i.e., shipment pattern analysis (Elzinga and Hogarty 1973) and transport cost (Rodrigue et al. 2016). Based on the shipment pattern analysis, a hypothetical geographical market is an area where suppliers carry out a major part of their

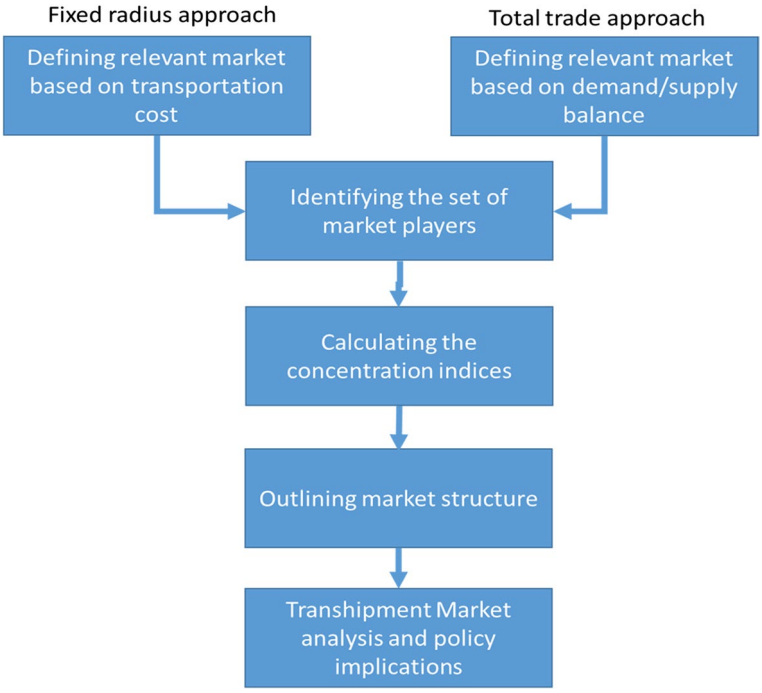

Fig. 3 Different approaches to analyze transhipment markets

economic activity, and only a smart part of the corresponding products/services consumed within the market is imported from outside. In principle, in this analysis, if imported shipments are substantial, this would place them in the same economic market (Elzinga and Hogarty 1973).

Assessing transport costs is an alternative to the shipment pattern analysis (Niels et al. 2011). Under this method, the hypothetical market around a demand point is extended to include new supply points, as long as the cost to the customer (which is the price of that supplier plus transport costs) is not significantly higher than that of the pre-included supply points (Fig. 4) (Rodrigue et al. 2016).

In this paper, we apply two different approaches to define the transhipment market. In the first approach, we consider the transhipment market as a circle-shaped area with a fixed radius, and terminals in that area are considered to be the market players. The radius of this market is determined based on transport cost and IFT break-even distance. The latter distance is the distance when the total cost of intermodal transport is equal to the cost of truck-only transport (Kim and Van Wee 2011). In other words, all terminals around a demand point "D", for which the total IFT cost is less than truck-only transport, are in the same transhipment market (Fig. 5). All these terminals (e.g., terminals A, B, and C in Fig. 5) compete with each other to supply transhipment services to the companies located at the demand point "D". This method can be used in cases where there is a lack of disaggregated data or inconsistencies in existing data, for example, demand data, or freight flows.

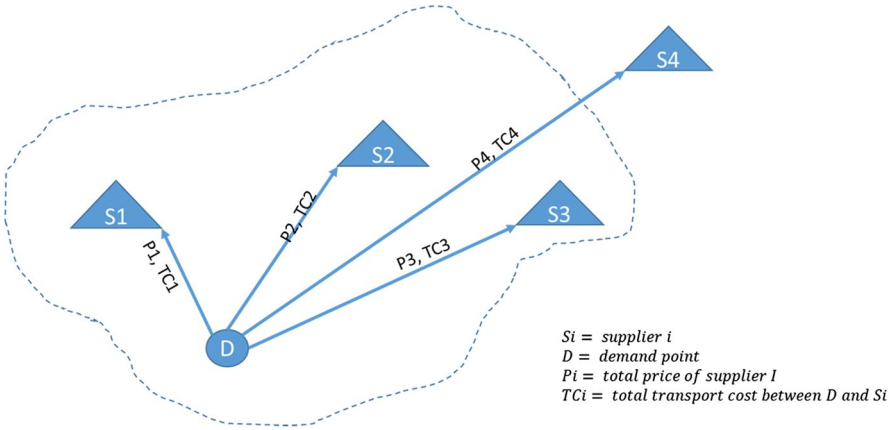

Fig. 4 Defining market based on the transport cost. *Source* Authors own illustration

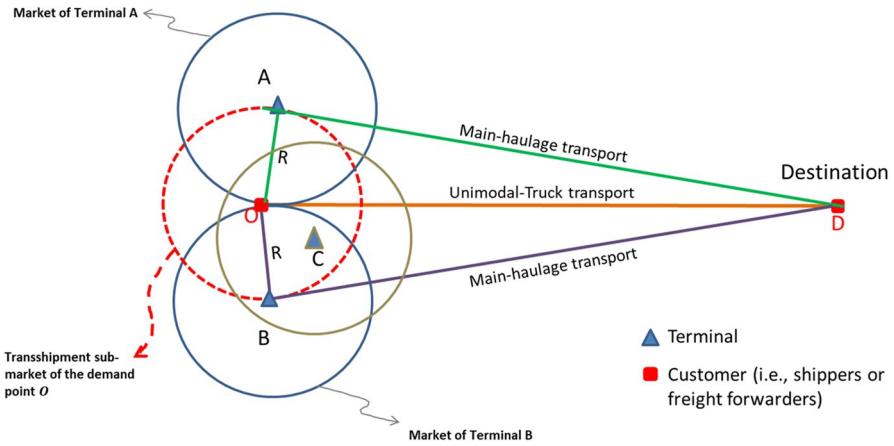

Fig. 5 Conceptual transhipment submarket around the transhipment demand points

In the second approach, assuming geographic transhipment markets expand contiguously, we apply shipment pattern analysis. In this method, known as the "total trade approach," the radius of the transhipment market is defined based on the balance between the demand for transhipment services and the throughput of existing transhipment service providers (i.e., inland terminals). Therefore, instead of a fixed market radius, we may have a different market radius for different demand points, and the radius of the market is extended until the cumulatively utilized capacity of the terminals in the area equals transhipment demand. The corresponding terminals are considered as market players.

Table 1 Defining market structure types based on the shepherd definition

Condition	Market type
$CR_4 < 25\%$	Not-oligopoly
$25\% < CR4 < 60\%$ and $HHI < 1000$	Loose oligopoly
$CR4 > 60\%$ and $HHI > 1800$	Tight oligopoly
$CR2 > 80\%$ or $CR3 > 90\%$	Super tight oligopoly
$40\% < CR1 < 99\%$	Dominant player

3.2 Calculating the concentration indexes for the identified markets

After the market players in a transhipment market are determined, we need to evaluate the concentration in that market. Concentration refers to a situation in which a few producers or service providers represent a large share of economic activity expressed in terms of, for example, cargo handling capacity (Sys 2009). Two well-known and frequently used indexes to measure the degree of concentration in a market are the concentration ratio and the Herfindahl–Hirschman index (US Department of Justice and the Federal Trade Commission 2010).

The concentration ratio CR_x, is the sum of the market shares of the X largest players. Typically, the CR is calculated for the 4 largest players (CR_4). Yet, in some cases, the information provided by this measure can be limited. This is mostly due to fact that this index does not give any information about smaller market players or the relative sizes of the firms in the industry. For example, two markets with the same CR_4 may have structural differences because one market may be an oligopoly while the other may have a dominant firm and many small ones. The Herfindahl–Hirschman index (HHI) addresses the shortcomings of the CR and looks into the market shares of all firms, large or small. Thus, the index is defined as the sum of the squares of the market shares of all players in the market. It is given by, $HHI = \sum_{i=1}^{n} (s_i)^2$, where the market shares (s_i) satisfy $\sum_{i=1}^{n} s_i = 1$.

3.3 Determining the market structure

Based on the range for CR and HHI indexes, Shepherd (1999) suggest different categories for market structure (Table 1).

In addition to the categorization of Shepherd (1999), the US Department of Justice Convention presents another categorization of market structures in its report "Horizontal Merger Guidelines" (US Department of Justice and the Federal Trade Commission 2010). The report is aimed at analyzing the market implications of mergers and their influence on market structure. Based on this report, an HHI index below 1500 reflects un-concentrated markets; an HHI index between 1500 and 2500 implies moderate concentration; while an HHI index above 2500 means that the market is highly concentrated (Table 2).

Table 2 Different market types based on the US department of justice convention

Condition	Market type
HHI < 1500	Un-concentrated
1500 < HHI < 2500	Moderately concentration
HHI > 2500	Highly concentrated

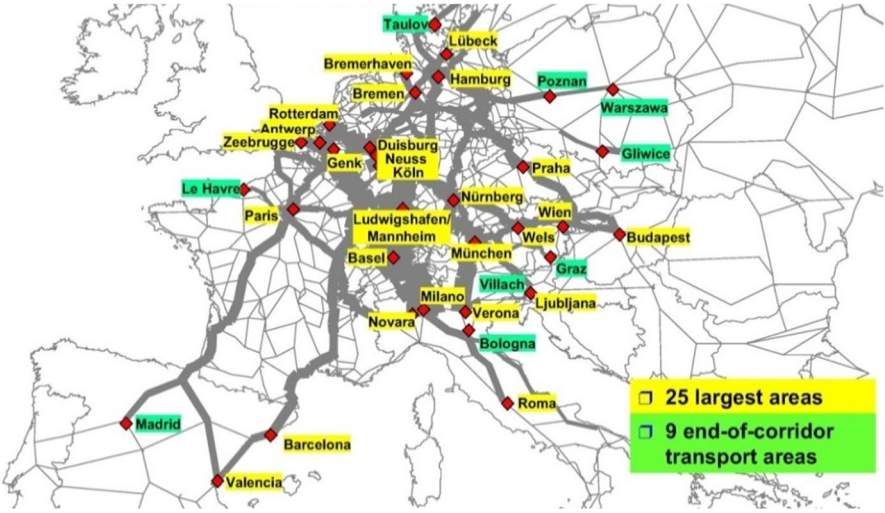

Fig. 6 EU main transport areas link to the main corridors. *Source* International Union of Railways (2004)

3.4 Transhipment market analysis and policy implications

Implementing effective policies could increase the competitive position of IFT, leading to an increase in its market share. Our approaches can be applied as practical instruments, to assist policymakers and practitioners to discover those the transhipment areas on which to focus their competition policies. They can also use these tools to evaluate the impact of their policies during a certain period.

4 Transhipment market analysis: a European case

In this section, we apply the presented methods to a case in the European IFT system. There are 18 main corridors in the EU where the majority of the IFT takes place (Fig. 6). The corridors connect 34 demand areas, consisting of the 25 largest areas, while 9 are end-of-corridor areas—where about 85% of the total IFT demand occurs.

4.1 Data description

In this study, we have included the 25 largest areas. In each region, we identified the most important inland terminals by using the Inlandlinks website (www.inlandlinks.com) and collected the capacity data for each terminal. We collected missing capacity data of some terminals from other sources, such as the intermodal-terminals website (www.intermodal-terminals.eu), the homepage of different terminals, and emails received from terminal operators.

In the study on IFT infrastructure of the EU report (International Union of Railways 2004), there were data on the aggregate demand[1] from 25 main markets in 2002, and estimates for 2015. To convert the data from tonnes to TEU, the data of unaccompanied combined transport (CT) by market segment in 2011 (International Union of Railways 2012) was used. Based on combined transport as given in the EU report (International Union of Railways 2012), the companies of unaccompanied European CT carried a total of 18,116,920 TEU on domestic and international combined transport services in 2011. This volume, in terms of tonnes, is a total of 191,842,030 gross tonnes. By dividing these two numbers, we have a good approximation for tonnes to TEU, which is 10.6 (Appendix 1).

While building a comprehensive database of unique and comparable data, also for the sake of simplification, it was necessary to make certain assumptions:

- The relevant market in each area is defined as a circle around its demand center.
- To calculate the distances between the 25 areas and the terminals, the Inlandlinks website measures the distance between the center of the area and the terminal. This implies that the total demand in each area is generated at the center of that area.[2]
- The utilization of terminals is considered to be 80% (Wiegmans and Behdani 2017).
- We assume that volumes originate from, or have their destination, within the region close to the terminal (radius is 70 km).

4.2 Applying two approaches to analyze the transhipment markets

Our two approaches (fixed radius and total trade) are applied in an attempt to define the transhipment market. To define the market in the first approach, following the works of (Janic 2007, 2008), terminals within 70 km are included in the analysis. This is followed by the assumption that inside the EU IFT network, distances between origins and destinations are in the range of 650 to 1050 km. For the sensitivity analysis of the transhipment market size (as a function of the radius), these calculations are also performed for terminals within a 50 and a 90 km radius. In the second approach, after sorting the terminals, the aggregate throughput is calculated.

[1] Measured in tonnes.

[2] This assumption is needed because the exact distribution of demand points (i.e., shippers or freight forwarders) in each area is not available or very difficult to access.

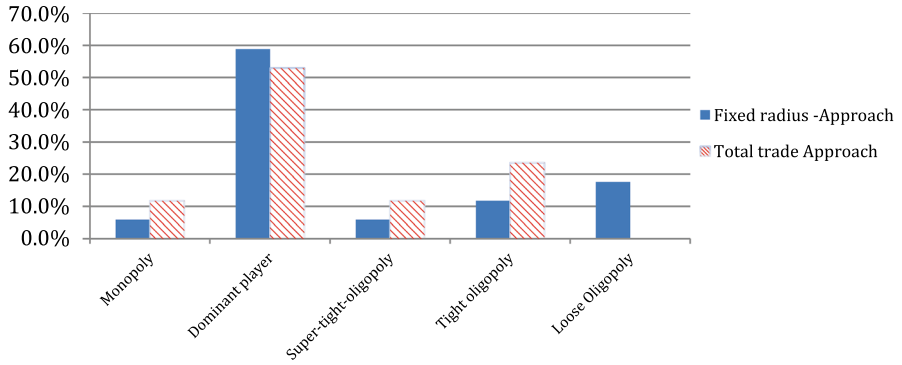

Fig. 7 Distribution of different transhipment market types based on Shepherd's definition

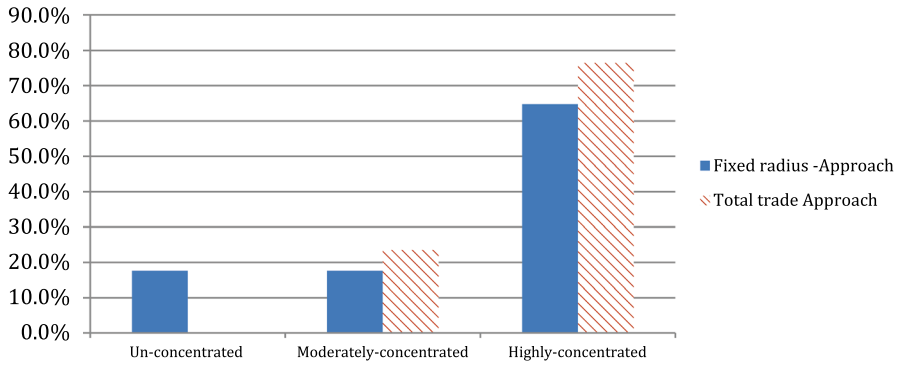

Fig. 8 Concentration level of different transhipment markets based on the US Department of Justice's definition

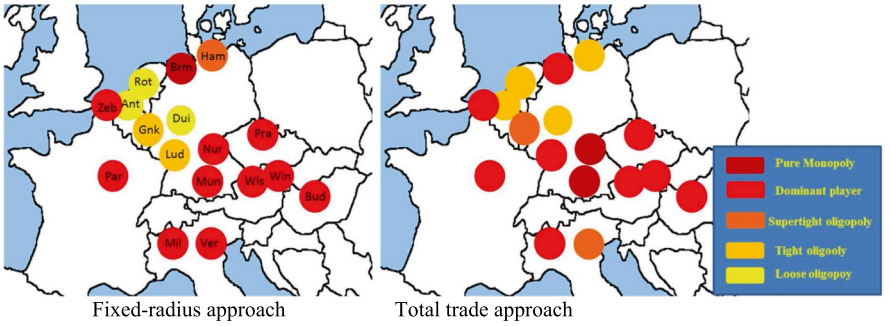

Fig. 9 Map of the structure of transhipment markets based on the fixed-radius approach (left) and total trade approach (right)

Table 3 Distribution of transhipment markets—radii based on the second approach

Radius (km)	No. of transshipment markets	Distribution (%)
≤25	8	47.1
25–50	2	11.8
50–70	2	11.8
70–90	2	11.8
90≥	3	17.6

The terminals included in this aggregation are considered as the market players and their market shares are calculated.

To study market concentration, we apply the CR_x, for $x=1, 2, 3, 4$, and the HHI index on our data. The concentration indexes of different transhipment markets based on the two approaches are presented in Appendix 2.

Based on these data, the different market structure types of transhipment markets have been determined using the Shepherd and the US Department of Justice definitions. As shown in Figs. 7, 8, 9, European transhipment markets range from loose oligopolies to pure monopolies. Based on the first approach, there is just one pure monopoly market (Bremerhaven), but according to the second approach, there are two, i.e., Nurnberg and Munchen.

According to the first approach, 11 terminal markets (65%) are either monopolies or dominant firm oligopolies (i.e., highly concentrated markets); about 18% are tight or super tight oligopolies. The second approach also leads to similar results: about 65% of the transhipment markets are monopolies or oligopolistic markets with a dominant player. Additionally, according to both approaches, it can be inferred that the major inland railroad terminals in the EU are active in highly concentrated transhipment markets (Fig. 9). Furthermore, it can be concluded that transhipment markets in northern EU are relatively more competitive than in central and southern areas.

To analyze the impact of the choice of a market radius in the first approach, we performed a sensitivity analysis with radii of 50 km and 90 km. The analysis showed that, in 82% of the areas, the structure of the markets is not sensitive to the length of the radius. By increasing the radius to 90 km, the concentration indexes decrease to a level that leads to a change in market structure in only three cases (Genk, Ludwigshafen, and Zeebrugge). By decreasing the radii to 50 km, market structure is changing in three areas (Duisburg, Nurnberg, Verona). Detailed data on the sensitivity analysis of different markets can be found in Appendix 3.

Other investigations in the transhipment markets involve analyzing the distribution of the markets in the second approach (total trade approach) based on different radii. In light of the literature on the IFT break-even distance, and the pre/post haulage distance estimations (e.g., Janic 2007, 2008; Kreutzberger 2008; Kim 2010), we have categorized the radii of different transhipment markets into five categories. As presented in Table 3, around 47% of the markets in the second approach are included in a circle with a 25 km radius, about 12% are

between 25 and 50 km radius, about 12% within the 50–70 km radius only, 12% in the 70–90 km radius, while 18% is in the more than 90 km radius category. Accordingly, we can conclude that most of the transhipment markets (more than 70%) are defined in the neighborhood areas with a radius of 70 km, which supports the first approach of this research.

5 Conclusions and further research

We have presented two methods for analyzing the structure of transhipment markets. From this analysis, one could point out the following conclusions:

- The results of two different approaches to transhipment market analysis support each other. This validates both approaches and, depending on data availability, one can select one or the other.
- The 70 km is a good approximation of the radius of the inland transhipment markets in the EU.
- In general, inland transhipment markets in the EU are oligopolistic in nature, and most of them are highly concentrated. The northern areas of the EU are, in general, less concentrated than the central and southern areas. This implies that the latter areas ought to give higher priority in defining policies to arrive at a more competitive transhipment market.

The presented methodologies can be used by policymakers to evaluate transhipment market structures. Our methodologies can also be used by antitrust authorities to assess possible anti-competitive behaviors by terminal operators in the IFT network. Considering that in most EU areas transhipment markets are highly concentrated, the EU transport policy and the national policies of EU members should focus more on transhipment areas, and more public and private funds should be allocated to the development of the new terminals. The approaches presented in this paper could be extended and applied in other IFT submarkets such as the pre/post haulage market. Future research could also focus on more areas within the EU market. It could include main haulage and corridors when defining the market and calculating market concentration.

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Appendix 1: Top transhipment market areas with respect to their total IFT trade in 2015

No	Transport area	Total trade TEU 2015
1	Rotterdam	1.384.623
2	Verona	1.108.208
3	Antwerpen	1.065.000
4	Hamburg	1.030.189
5	Milan/Novara	3.234.623
6	Praha	458.208
7	Mannheim/Ludwigshaf	433.113
8	Zeebrügge	404.717
9	Paris	365.094
10	Basel	357.170
11	Barcelona	330.849
12	Valencia	286.981
13	Genk	281.698
14	Nürnberg	257.830
15	Bremen/Bremerhaven	237.453
16	Roma	216.981
17	München	206.509
18	Koln/Neuss/Duisburg	1.644.717
19	Wien	193.208
20	Wels	176.226
21	Budapest	169.811
22	Ljubljana	148.679
23	Other transport areas	5.359.528
Total		19.351.415

Appendix 2: Different structures of transhipment markets in the EU IFT network

Market area	Based on the first approach (fixed radius)						
	CR1 (%)	CR2 (%)	CR3 (%)	CR4 (%)	HHI	Shepherd	US Department of justice convention
Antwerp	17.6	32.8	44.6	51.9	779	Loose oligopoly	Un-concentrated
Bremerhaven	100.0	–	–	–	10.000	Monopoly	Highly concentrated

Market area	Based on the first approach (fixed radius)						
	CR1 (%)	CR2 (%)	CR3 (%)	CR4 (%)	HHI	Shepherd	US Department of justice convention
Budapest	59.5	100.0	–	–	5.179	Dominant player	Highly concentrated
Duisburg/Koln/Neuss	22.4	35.2	44.8	52.8	1.074	Loose oligopoly	Un-concentrated
Genk	42.0	65.3	73.3	81.4	2.528	Tight oligopoly	Moderately concentrated
Hamburg	34.2	63.9	85.5	92.7	2.598	Super tight oligopoly	Moderately concentrated
Ludwigshafen	27.1	46.3	65.1	77.6	1.752	Tight oligopoly	Moderately concentrated
Milano/Novara	52.1	74.8	86.1	93.2	3.431	Dominant player	Highly concentrated
Munchen	76.1	89.4	95.6	100.0	6.027	Dominant player	Highly concentrated
Nurnberg	92.3	100.0	–	–	8.587	Dominant player	Highly concentrated
Paris	83.9	93.5	97.1	100.0	7.158	Dominant player	Highly concentrated
Praha	65.1	84,5	98.8	100.0	4.816	Dominant player	Highly concentrated
Rotterdam	19.7	39.5	53.3	65.1	1.366	Loose oligopoly	Un-concentrated
Verona	70.7	100.0	–	–	5.856	Dominant player	Highly concentrated
Wels	66.6	99.96	100.0	–	5.549	Dominant player	Highly concentrated
Wien	70.5	100.0	–	–	5.840	Dominant player	Highly concentrated
Zeebrugge	78.4	100.0	–	–	6.617	Dominant player	Highly concentrated
Antwerp	17.6	32.8	44.6	51.9	779	Loose oligopoly	Un-concentrated

– Not relevant for the calculation

Market area	Based on the second approach (total trade)						
	CR1 (%)	CR2 (%)	CR3 (%)	CR4 (%)	HHI	Shepherd	US Department of justice convention
Antwerp	29.3	46.9	62.2	73.9	1673	Tight oligopoly	Moderately concentrated
Bremerhaven	50.5	75.2	90.1	100.0	3481	Dominant player	Highly concentrated

Market area	Based on the second approach (total trade)						
	CR1 (%)	CR2 (%)	CR3 (%)	CR4 (%)	HHI	Shepherd	US Department of justice convention
Budapest	59.5	100.0	–	–	5179	Dominant player	Highly concentrated
Duisburg / Koln/ Neuss	31.0	48.7	59.7	70.8	1644	Tight oligopoly	Moderately concentrated
Genk	35.7	71.4	100.0	–	3367	Super tight oligopoly	Highly concentrated
Hamburg	24.8	46.3	62.0	70.2	1510	Tight oligopoly	Moderately concentrated
Ludwigshafen	73.0	100.0	–	–	6061	Dominant player	Highly concentrated
Milano/Novara	45.6	65.5	75.4	82.1	2695	Dominant player	Highly concentrated
Munchen	100.0	–	–	–	10,000	Monopoly	Highly concentrated
Nurnberg	100.0	–	–	–	10,000	Monopoly	Highly concentrated
Paris	86.4	96.3	100.0	–	7580	Dominant player	Highly concentrated
Praha	65.9	85.5	100.0	–	4935	Dominant player	Highly concentrated
Rotterdam	28.2	56.3	76.1	87.3	2184	Tight oligopoly	Moderately concentrated
Verona	38.4	54.3	70.2	85.5	2424	Super tight oligopoly	Highly concentrated
Wels	66.6	99.96	100.0	–	5549	Dominant player	Highly concentrated
Wien	70.5	100.0	–	–	5840	Dominant player	Highly concentrated
Zeebrugge	83.1	96.3	100.0	–	7088	Dominant player	Highly concentrated
Antwerp	29.3	46.9	62.2	73.9	1673	Tight oligopoly	Moderately concentrated

– Not relevant for the calculation

Appendix 3: Sensitivity analysis of market structure in terms of radius of transhipment market area

Market area	Market type with fixed radius 70 km		Market type with fixed radius 90 km		Market type with fixed radius 50 km	
	Shepherd	US Department of justice convention	Shepherd	US Department of justice convention	Shepherd	US Department of justice convention
Antwerp	Loose oligopoly	Un-concentrated	Loose oligopoly	Un-concentrated	Loose oligopoly	Moderately concentrated
Bremerhaven	Monopoly	Highly concentrated	Monopoly	Highly concentrated	Monopoly	Highly concentrated
Budapest	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Dominant player	Highly concentrated
Duisburg	Loose oligopoly	Un-concentrated	Loose oligopoly	Un-concentrated	Tight oligopoly	Moderately concentrated
Genk	Tight oligopoly	Moderately concentrated	Loose oligopoly	Un-concentrated	Tight oligopoly	Highly concentrated
Hamburg	Super tight oligopoly	Moderately concentrated	Super tight oligopoly	Moderately concentrated	Super tight oligopoly	Moderately concentrated
Ludwigshafen	Tight oligopoly	Moderately concentrated	Loose oligopoly	Un-concentrated	Tight oligopoly	Moderately concentrated
Milano	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Dominant player	Highly concentrated
Munchen	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Dominant player	Highly concentrated
Nurnberg	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Monopoly	Highly concentrated
Paris	Dominant player	Highly concentrated	Dominant player	Highly Concentrated	Dominant player	Highly concentrated
Praha	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Dominant player	Highly concentrated
Rotterdam	Loose oligopoly	Un-concentrated	Loose oligopoly	Un-concentrated	Loose oligopoly	Un-concentrated
Verona	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Monopoly	Highly concentrated
Wels	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Dominant player	Highly concentrated
Wien	Dominant player	Highly concentrated	Dominant player	Highly concentrated	Dominant player	Highly concentrated
Zeebrugge	Dominant player	Highly concentrated	Tight oligopoly	Moderately concentrated	Dominant player	Highly concentrated

Market area	Market type with fixed radius 70 km		Market type with fixed radius 90 km		Market type with fixed radius 50 km	
	Shepherd	US Department of justice convention	Shepherd	US Department of justice convention	Shepherd	US Department of justice convention
Antwerp	Loose oligopoly	Un-concentrated	Loose oligopoly	Un-concentrated	Loose oligopoly	Moderately concentrated

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