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Analyzing competition in intermodal freight transport networks: the market implication of business consolidation strategies

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Abstract

To cope with an intense and competitive environment, intermodal freight transport operators have increasingly adopted business practices —like horizontal and vertical business integration—which aim to reduce the operational costs, increase the profit margins, and improve their competitive position in the market. These strategies and business practices could potentially affect the competition level in the IFT market by increasing the market concentration. The impact can be on the separate submarkets (e.g., transshipment market or main-haulage market) or the whole market for IFT services at the network level. To investigate the impact of these business practices on the market structure of IFT networks, we present a model to analyze the market structure of IFT submarkets and extend the results to the network level. Using this multi-level market analysis model, we can evaluate the decisions made by firms and the market outcomes that result. The application of the presented model is also illustrated using a numerical example. The numerical example shows, for instance, that the impact of a merger, as a business practice, on the competition level in an IFT market —and its submarkets— depends on the merger type (horizontal and vertical). Furthermore, different indicators that "represent" market structure and competition, might react differently to a merger in an IFT network.

1. INTRODUCTION

Global freight transport has grown steadily in the last two decades [1]. Because road transport has been the dominant modality for hinterland transport, this growth has resulted in congestion and other external effects such as emissions and noise nuisance [2]. Intermodal freight transport (IFT) involving rail and inland waterways as the main transport links is believed to provide an attractive alternative to road transport [3]. In particular, the European Commission has initiated a considerable number of research programs that are designed to stimulate IFT ([4], [5]). Also, growing attention has been paid to develop new practices for the design, planning, and execution of IFT and its performance [6]. Many IFT operators have increasingly adopted business practices to improve their competitive position in the market by reducing the operational costs and increasing the profit margins. Some of these IFT business practices, for example, mergers and acquisitions and other horizontal and vertical business integrations, could lead to market structure changes and decrease the competition level in the IFT network. Antitrust authorities may scrutinize and limit such practices, because they could harm consumer welfare [7]. Antitrust authorities evaluate the decisions made by firms, based on the expected market structure outcomes.

The analysis of market structure and concertation measures for IFT service can be done at several different levels. First, the analysis can be performed for separate segments (e.g., the market for transshipment operators or the market for main-haulage operators). Some literature has analyzed specific segments of IFT markets; see for example [8], [9], [10], [11]. However, due to the multistage characteristic of IFT services, the segmental analysis gives an incomplete view of the IFT market. Moreover, none of these papers has explicitly studied the impact of business practices on the IFT market structure. To fill these gaps, we present a model that analyses IFT services at the network level, and we refer to it as the Intermodal freight transport market structure (IFTMS) model.

First, we distinguish a number of submarkets that correspond to the services provided: pre-haulage, end-haulage, transshipment, main-haulage, and so on. Second, the IFTMS model incorporates a flow optimization model to assign the capacities on links, nodes, and paths to the IFT network services in a consistent way. Next, the concentration indices—like CR or HHI [12]—for these IFT submarkets are calculated. The Concentration Ratio Index (CR_x) is the sum of the market shares of the x largest players, and the HHI is the sum of the squares of the market shares of all players in that market. In this manner, the model helps analyze the IFT market at the network level. We can also measure the impact of anticompetitive practices on the market structure of the IFT network.

The paper is structured as follows. Section 2 concerns the literature review, and Section 3 introduces the IFTMS model to analyze the market structure of the IFT network. In Section 4, we apply our model to an illustrative example case to measure the impact of horizontal and vertical integration on market structure and competition level of the IFT network and its submarkets. Finally, the last section presents the conclusions and management implications and indicates further research directions.

2. Literature Review

2.1. Intermodal Freight Transport Market Structure Analysis

Intermodal freight transport (IFT) is defined as "unitized freight transport by at least two transport modes" [4]. In the IFT market, different actors (pre- and end-haulage operators, main-haulage operators, terminal operators, and intermodal operator) are active in their respective submarkets (see Figure 1) to deliver door to door continental transport service. The IFT market encompasses all actors operating in all submarkets.

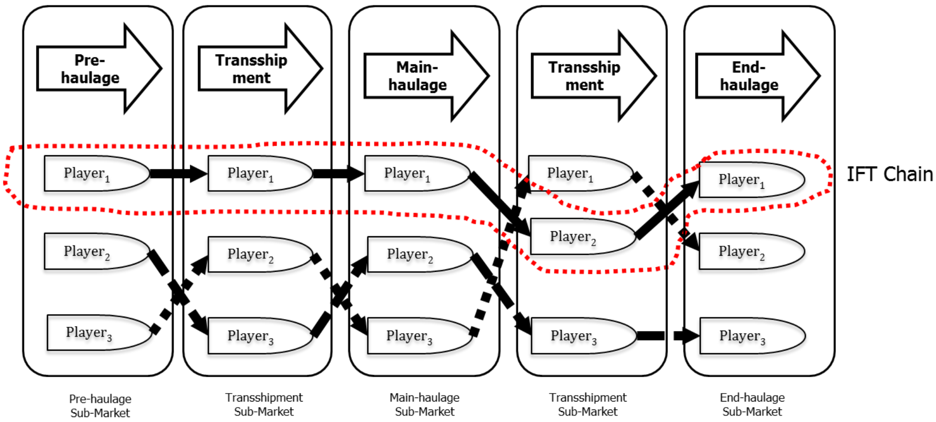

Fig. 1 .Different actors inside a corridor of an IFT network
Source: adapted from Chandrashekar and Schary [13]**.**

In the competition literature, the term "relevant market" is used to describe areas where competition takes place [8]. This relevance lies in both the product or service and the geographic dimensions. In market theories, there are traditionally four main categories of market structure: perfect competition, monopolistic competition, oligopoly, and monopoly [14]. Sometimes, the oligopoly market is divided into subcategories. For example, Shepherd [15] categorized oligopoly into loose oligopoly, tight oligopoly, super tight oligopoly, and dominant player oligopoly. Ultimately, the structure of a market will be determined based on the degree of market concentration. Only a few scientific papers have contributed to the structural analysis of (parts of) the IFT market. For example, Wiegmans et al. [9] analyzed the IFT market in the EU qualitatively based on an extended version of Porter's model of the competitive forces to identify the stakeholders in the terminal market and find the potential for economic benefits. Makitalo [10] investigated the Finnish rail industry market by using Delphi techniques and revealed the largest market entry barriers. According to Macharis and Bontekoning [2], most papers analyze only selected parts of IFT, but there is no paper that analyzes business practices in the whole IFT market. In several other research studies (e.g., [16], [17], [18], [19], [20], [21]), parts of the IFT network are modeled and optimized. In the supply chain literature, competition between supply chains is defined (see e.g., [22], [23]). Rice and Hoppe [24] show that supply chain competition does not have a unique definition. They have undertaken a Delphi study among supply chain experts from industry and academia to find different interpretations of the concept of competition among supply chains. The findings reveal that supply chain versus supply chain is not the only existing form of competition, and the methods that companies use to compete are complicated. They categorized the findings in three different categories: actual competition between supply chains, competition in supply network capabilities, and competition in supply chain capabilities led by the master channel (the company that is most powerful on a supply network). Our focus is on the first category as actual competition among IFT chains. Another interesting work about competition among supply chains is the paper by Antai [25]. He has developed a conceptual model for competition among supply chains using the ecological niche approach. In his approach, the source of the competition is the overlap in the resources that are used by different supply chains. Then, by presenting indices and measures, such as niche breadth and niche overlap, he defines the index of competition among two supply chains. "Niche breadth" is a set of different resources that a supply chain uses, and "niche overlap" is an index that shows the degree of overlap between the niche breadth of two different supply chains. The idea concerning the source of competition is further elaborated when we analyze concentration inside the transshipment (node) and main-haulage (link) submarkets.

Market concentration refers to the extent to which a certain number of producers or service providers represent certain shares of economic activity expressed in terms of, for example, volume (i.e., the throughput of different players) [12]. Other indicators such as capacity, revenue, added value, capital cost, or other financial or nonfinancial indices can also be used to calculate the degree of concentration in the IFT market [26]. In this paper, we use the volume of different players as indicator. There are many indices to measure the degree of concentration, such as the Gini Index, the Concentration Ratio Index, the Herfindahl-Hirschman Index, and the Entropy Index. The most often used ones are the Concentration Ratio Index (CR) and the Herfindahl-Hirschman Index (HHI) [27]. Typically, the concentration index is calculated for the four largest players (CR_4). The main disadvantage is that two markets with the same high CR_4 levels may have a structural difference because one market may have few players, whereas the other may have many players.

The HHI is defined as:

$$HHI = \sum_{i=1}^{n} (s_i)^2 * 10000, \qquad (1)$$

where the market shares (s_i) satisfy $\sum_{i=1}^{n} s_i = 1$. To simplify the reading, it is multiplied by 10,000.

The main disadvantage of HHI is that it shows little sensitivity to the entrance of small players into the market [15]. Because of shortcomings of separate measures, it is common to employ multiple indicators in market structure analysis. Merikas et al. [11] investigated the change in the structure of the tanker shipping market and its impact on freight rates by applying the CR index and the HHI index. They found that market concentration has increased since 1993. Sys [8] studied whether the container liner shipping industry as a unimodal freight transport system is an oligopolistic market. She used concentration indices and based on the degree of concentration, made judgments about the market structure. Similar to Sys [8], in this paper we use the concentration indices for market analysis, but the calculations are extended from separate submarkets to IFT networks.

2.2. Intermodal Freight Transport Business Strategies

Business integration practices may aim to reduce cost and risks, or to realize scale economies [28]. Furthermore, they may lead to value optimization, improved service levels, visibility, and customer satisfaction [29]. Both horizontal and vertical business integrations can take several forms ranging from light to heavy. Subcontracting (supplier relation) is a light form of business integration and aimed at the short term. Stronger forms of business integration might be strategic alliances or joint ventures. The heaviest form of business integration is a merger or acquisition.

IFT business strategies and their effects on the structure of the IFT market is a subject not often discussed in scientific literature. This is remarkable, considering the large importance given by IFT business managers and policy makers, and taking into account the large number of IFT practices initiated by different decision makers at different levels (i.e., governmental policy makers and business managers) all over the world. In a recent research into competition and horizontal integration in maritime freight transport, Alvarez-San Jaime et al. [30] found that the benefits of a merger depend on the size of the scale economies and on the differentiation of services. In another research, Alvarez-San Jaime et al. [31] found that vertical integration in maritime freight transport (shipping and terminals) leads to (1) continuing routing of cargo through the open terminal and (2) keeping terminals nonexclusive.

Despite the limited amount of research in this domain, there have been several practical cases in recent years in which adopting some business practices has potentially led to change in the market structure. Three interesting cases that have been restricted by the Dutch antitrust authority are (1) takeover of TNT by UPS, (2) handling barges at ECT, and (3) coordinated barge transport between a number of inland terminals in Brabant and the port of Rotterdam. An interesting case in the transportation sector—in terms of antitrust competition policy—is the failed takeover of TNT by UPS. EU antitrust authorities said the deal would most likely lead to overconcentration in the sector, which saw UPS offering to sell parts of the company's small-packages and airline business in return, but that was not enough [32]. In terms of business competitors operating on a European scale, this would indeed lead to just a small number of remaining competitors. However, on national scale, for example, many more operators are still competing in these markets. Another example is the recent check, by the EU, of quay loading and unloading procedures for barges at the quays of ECT [33]. It is investigated whether barges belonging to the Extended Gate Service (EGS) of ECT are treated more favorably than non-EGS barges. Another example is the cooperation of a number of inland container terminals in Brabant that organize their inland waterway transport to and from Rotterdam together [34]. Especially this case could be analyzed from three different perspectives: (1) horizontal business integration between nodes (the inland terminals), (2) horizontal integration between different links (inland waterway transport to and from Rotterdam), (3) vertical integration between nodes and links (terminals and inland waterway transport).

3. MEASURING MARKET CONCENTRATION ON IFT NETWORKS: IFTMS MODEL

In this section, we present a model using graph theory that decomposes the IFT network into distinct submarkets and assigns the capacities to the IFT network. The results are next used to calculate the concentration indices for different submarkets. In previous studies, for example, Crainic [35], IFT services (pre- and end-haulage, transshipment, and main-haulage) have been modeled using graphs. A graph consists of nodes (terminals executing transshipment) and links (transport processes) where nodes are connected by links. This paper takes a slightly different stance. We consider each transshipment submarket, which includes multiple terminals, as a node in the model. The main-haulage transport between two nodes is provided via a link that represents a main-haulage submarket. This submarket may include rail or inland waterway transport operators. On the network market level, corridors are defined as sequences of nodes and links from origin to destination. Different combinations of operators inside these nodes and links are considered as IFT chains (Figure 2). In reality, these IFT chains are organized by intermodal transport operators who integrate transshipment and transport operations. Certain origins and destinations can often be connected via multiple corridors. This means that in the network level—based on competing entities—we have two different types of submarkets: (1) the corridor submarket (competition between IFT chains) and (2) the origin-destination submarket (competition between corridors).

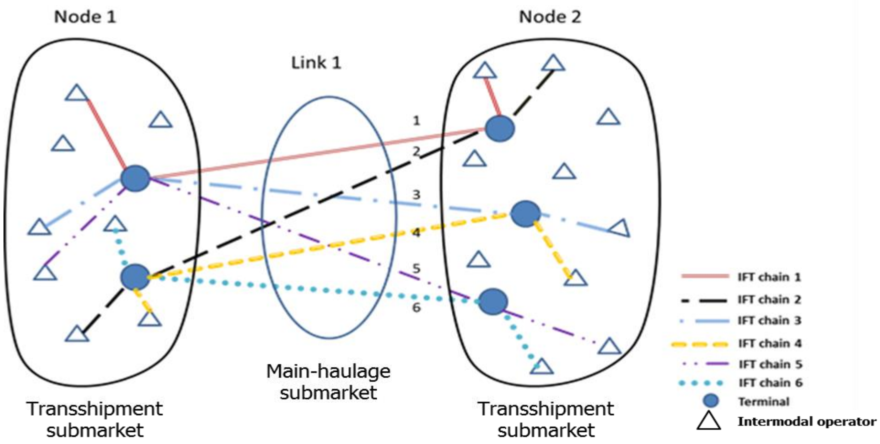

Fig. 2 .Different Submarkets inside an IFT network

By representing IFT processes (transshipment, main haulage, and logistics) with graph theory concepts (node, link, and network), we connect different submarkets on the IFT network. To assess market concentration we need to have the volume (throughput) of each player (e.g., a main-haulage operator) in different submarkets. For this purpose we use a network flow model, which is discussed in the following section.

3.1. Network Flow Assignment

The flow assignment in a network with certain capacities for nodes and links can be done in various ways [36]. We will do it in a proportional and consistent way by applying a proportional fairness algorithm [37]; that is, the amount of flow allocated to competing operators will be proportional to the capacities of these operators. In particular, we will allocate flow in such a way that assigning more flow to a corridor increases the total utility of the network more than assigning to any other corridor [37]. We now formalize.

The network is given by graph $G = (N, A)$ with node set N and link set A. The flow f_a on link a ∈ A does not exceed link capacity, that is, $0 \leq f_a \leq c_a$. For any node $n \in N$, the flow is also assumed to respect capacity, so $0 \leq f_n \leq c_n$ for $n \in N$.

For any corridor $\pi \epsilon \prod$ that originates from o and is destined to d, we may establish a flow f_π through the corridor. By abuse of notation, we write $a \in \pi$ or $n \in \pi$ whenever the link a or the node n is part of the corridor π. Define the link-corridor (and similarly, node-corridor) incidence matrix as follows: let $\delta_{a\pi} = 1$ whenever $a \in \pi$ and $\delta_{a\pi} = 0$ otherwise. The flows f_π satisfy $f_a = \sum_\pi \delta_{a\pi} f_\pi$ and $f_n = \sum_\pi \delta_{n\pi} f_\pi$. In case the incidence matrices have ranks equal to the number of corridors, which is the case when the corridors all connect the same OD-pair, then the corridor flows can also be constructed from the link (or node) flows by applying the right inverse of the link-corridor (node-corridor) incidence matrix.

The total flow of the network is the summation of the flows through all corridors, that is, $|f| = \sum_{\pi \epsilon \prod} f_\pi$. Alternatively, the flow size equals the total outflow from the origin and the total inflow to the destination, that is, $|f| = f_o = f_d$. A corridor π has capacity $c_\pi = min\{c_a, c_n | a \in \pi, n \in \pi\}$.

The allocation of the total flow $|f|$ to corridors is proportionally fair when [37]:

$$Max \prod_{\pi \epsilon \prod} f_\pi \ , \quad (2)$$

$$\sum_{\pi} \delta_{n\pi} f_\pi \leq c_n \ , \quad (3)$$

$$\sum_{\pi} \delta_{a\pi} f_\pi \leq c_a \ , \quad (4)$$

$$f_\pi \leq c_\pi \ , \forall \pi \epsilon \prod \ . \quad (5)$$

Hence, we maximize the product of the corridor flows, subject to three constraints. Equations (3) and (4) constrain the summation of the flows of the corridors using node n or link a to be less than or equal to the capacity of that respective node or link. Equation (5) forces that the assigned flows to the corridors not be more than the capacity of the corridors.

We argue that in this manner, the flow will be allocated to all corridors (see Equation 2), and our allocation mechanism does not introduce market concentration artifacts as flow is rationed proportional to available capacities. This will allow us to study market concentration as it emerges from the structure of the capacitated network.

3.2. Market Concentration Based on Flow Allocation to Different Businesses

The node (transshipment) submarket M_n has a flow size f_n and total capacity c_n. Each node has P_n players with the capacities c_n^k, where $k \in P_n$ are transshipment operators in the node. By definition, the flow of the player k inside node n is $f_a^k := f_n . c_n^k / c_n$. Similarly, for the link submarket M_a, we get $f_a^l := f_n \, c_a^l / c_a$ for main-haulage operators (rail and barge operators) $l \epsilon P_a$, and P_a is the set of all players in the link (main-haulage) submarket. Business operators in the OD-pair submarket M_{od} are identified with corridors, so the allocation of total flow to these businesses is equal to the allocation of flow to corridors, which we have previously discussed. A corridor π is associated with a sequence of nodes $(n_1, \dots, n_{m+1})$ and links $(a_1, \dots, a_m)$, where $a_j = (n_j, n_{j+1})$. A chain (p) within this corridor is associated with a service that uses capacities of certain operators inside nodes and links. If operators $k_i \epsilon P_{n_i}$ $(k_i \epsilon k, P_{n_i} \epsilon \ P_n)$ for $i = 1, \dots, m+1$, and $l_j \epsilon P_{a_i}$ $(l_j \epsilon l, P_{a_i} \epsilon \ P_a)$ for $j = 1, \dots, m$ provide capacity to chain p (and we write $p \epsilon \pi$), then the chain is given by $(c_{n_i}^{k_i}, c_{a_j}^{l_j})$.

We define the p_o as a chain with the least capacity inside the corridor π – i.e., a chain consist of players which have minimum capacity inside nodes and links:

$$p_o := \left\{ (c_{n_i}^{k_{io}}, c_{a_j}^{l_{jo}}) \middle| \ c_{n_i}^{k_{io}} = \min\left\{ c_{n_i}^{k_i} \right\}, c_{a_j}^{l_{jo}} = \min\left\{ c_{a_j}^{l_j} \right\}, i = 1, \dots, m+1, j = 1, \dots, m \right\} \quad (6)$$

Then considering these least capacity chain (p_o), we assign a weight to different chains, by dividing the capacity of the players in nodes and links to the capacity of the players inside least capacity chain (p_o), and then make a summation on these numbers.

$$w_p := \left\{ \sum_i \frac{c_{n_i}^{k_i}}{c_{n_i}^{k_{io}}} + \sum_j \frac{c_{a_j}^{l_j}}{c_{a_j}^{l_{jo}}} \ , \qquad p \in \pi \right\} \quad (7)$$

We allocate flow proportional to the weights, and we set the flow of the chain p in the corridor π as follows:

$$f_\pi^p := \frac{w_p}{\sum w_p} . c_\pi \quad (8)$$

Additional submarkets can be defined for those nodes and links that are bottlenecks in the corridors. These corridors effectively compete for capacity on those nodes and links. B denotes the set of bottlenecks in the network with respect to the flow f, that is,

$$B \coloneqq \{n \epsilon N | f_n = c_n\} \cup \{a \epsilon A | f_a = c_a\} \qquad (9)$$

We have for $a\epsilon A$ that $c_a = f_a = \sum_\pi \delta_{a\pi} f_\pi$ and for $n\epsilon N$ that $c_n = f_n = \sum_\pi \delta_{n\pi} f_\pi$. The allocation of link a (or node n) capacity to the corridor π is given by f_π.

4. ANALYZING THE EFFECT OF BUSINESS INTEGRATIONS ON IFT MARKET STRUCTURE: MODEL APPLICATION

To illustrate our IFTMS model, and assess the impact of different types of business integration on competition and market concentration of IFT network, an analysis has been made of relatively heavy business integration in a simplified IFT network with one origin and one destination.

4.1. Introduction: Simplified Network and Assumptions

Basic services offered by different businesses in an IFT network are pre- and end haulage, transshipment, and main haulage. These businesses may be aggregated to offer more comprehensive transport services from origins to destinations, which are shipper locations, sea terminals, or inland terminals. In this paper, we limit the scope of the model, and we make a number of simplifying assumptions regarding market organization because the market structure of the IFT network as explored in this paper is already quite complicated under these assumptions and limitations. We discuss more complex situations in further research opportunities in the concluding section of our paper.

First, we discuss our simplified network and its nodes, links, corridors, and origin and destination (see also Figure 3). The network consists of one origin and destination. In the network, we distinguish five nodes (O, A, B, C, and D). We also distinguish seven links (OA, OB, OC, AD, AB, BD, and CD). In the figure, also four corridors (OAD, OABD, OBD, and OCD) can be seen.

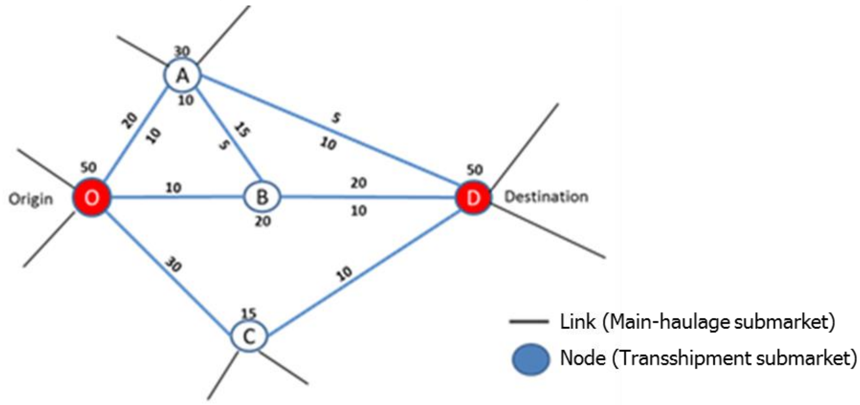

Fig. 3 .Conceptual Transport Network (capacity of each operator in nodes and links is in '000 TEU)

Given the large number of variables, the example is a relatively simple network that is expected to be further enlarged in future research. There are a number of important assumptions in the paper that are now consecutively discussed:

A simple business model is assumed. This means that each business operator (terminal operator, main-haulage operator, and intermodal operator) provides a single service. This implies that two different types of services, such as transshipment and main-haulage services, or main-haulage services on two different transport routes, are not offered by a single business operator. This results in our assessment of market concentration being conservative in the sense that we tend to underestimate the level of concentration in markets;

In our model, we consider areas in which a number of transshipment operators compete for intermodal transport unit (ITU) orders that originate from consigners or that are destined to consignees. We shall identify such an area (transshipment submarket) with a node in the network. In this case, we disregard the competition for pre- and end haulage, that is, the transportation between customers and the terminals within the area.

All operators are assumed to offer homogeneous services. In the case of IFT, the main-haulage between terminals is done by high-capacity transport modes such as barge and train. An important simplifying assumption is that the transport services using these modes all compete as perfect substitutes.

Each node corresponds with a transshipment submarket in which terminal operators compete while offering transshipment services, and a link corresponds with a main-haulage submarket in which carriers compete while offering transport services.

The market share of the different operators is measured by their throughput, which is assigned proportional to their capacity. The capacity of each link and node is the summation of the capacity of different business operators belonging to that node or link.

Differences between the transit times of respective corridors inside the OD pair submarket are not taken into account in this paper (but will be in future research).

Unimodal truck transport is not considered in this paper (but will be in future research).

The volume of transshipment of the respective terminal operators in a node (transshipment submarket) is representing their respective market shares. The freight volumes (flow) of transport operators on a certain link depict their respective market shares on that link (main-haulage submarket). The flows of organized IFT chains in a certain corridor represent the market shares in that corridor submarket. In intermodal freight transport, not all flows for all nodes and links are known. Therefore, we use capacities as a proxy. In the next sections, we apply the IFTMS model to measure market concentration in submarkets of the IFT network. We also measure the change in the market concentration indices resulting in anticompetitive horizontal and vertical merger practices in a simplified IFT network.

4.2. Horizontal Business Integration: Node and Link Concentration

In this section, the situation where two operators inside the same IFT submarket decide to merge, or one of them acquires the other, is analyzed (further referred to as merger). By means of an example, it is investigated how the degree of concentration inside different IFT submarkets will be affected, and it is shown how competition authorities could benefit from the model to investigate the consequences of a merger on competition and market concentration.

"Horizontal merger" means that two organizations in the same business merge. In our case, this implies that different operators' inside links or nodes merge with each other: for example, two different terminal operators in the same transshipment submarket (node) or two rail operators in the same main-haulage submarket (link) merge. In our example, we assume that the two rail operators inside link OA merge. How will the market concentration change inside different submarkets of the IFT network? This merger will affect the concentration inside the OA link (main-haulage submarket). Now, inside the OA link only one rail operator exists. The OA link belongs to the OAD and OABD corridors, so the merger also affects the concentration inside these two corridor submarkets. The merger reduces the number of IFT chains inside the OAD corridor from 8 to 4 and inside OABD corridor from 16 to 8. The other two corridors, OBD and OCD, are not affected. Also as a general result, the optimal flow set and the capacity of the network do not change directly because the optimal solution is related to the capacities of the links and nodes, regardless of their distributions between different operators inside links and nodes. However, after a merger, companies often realize efficiency gains, and in this respect, the merged rail company might reduce capacity, and as a consequence, the optimal flow set might change. The changing number of IFT chains inside the OAD and OABD corridors also has an effect on the concentration inside the OD pair submarket. Table 1 shows the concentration indices inside link OA, and corridors OAD and OABD, before and after the merger. In link OA, the concentration in terms of the CR Index increases by about 50% and in terms of the HHI increases by about 80%, which shows a high increase in concentration. Similarly, in the corridor OAD, a merger leads to a more concentrated market. In this corridor, the concentration in terms of the CR index increases by more than 75% and, in terms of the HHI, increases by 100%. In addition, in the OABD corridor, we see the same development. Concentration increases by at least 87% (CR index) and 100% (HHI), leading to a more concentrated market. However, in the OD pair submarket, there is no change in the concentration in terms of the $CR1$, $CR2$, and $CR3$ indices, and only a small change in terms of the $CR4$ index and the HHI, because the three largest IFT chains, which exist inside corridors OBD and OCD, are not affected by the merger inside link OA, and the capacities of these three chains are very high compared with the rest.

TABLE 1. Concentration indices Before and After the Horizontal Merger

Related Submarkets	Concentration indices	Values	
		Before	After
Link OA	CR1	67%	100%
	HHI	5578	10000
Corridor OAD	CR1	17%	31%
	CR2	31%	58%
	CR3	45%	81%
	CR4	57%	100%
	HHI	1287	2576
Corridor OABD	CR1	8%	16%
	CR2	16%	30%
	CR3	23%	43%
	CR4	30%	57%
	HHI	638	1280
O-D pair	CR1	22%	22%
	CR2	35%	35%
	CR3	47%	47%
	CR4	52%	57%
	HHI	805	837

* For an explanation, as a concrete example, of how for instance the CR1 is calculated for corridor OAD, see Annex A.

The results of the numerical example indicate that concentration degrees on certain links and nodes could already be high and probably might increase further due to a merger on a certain link or node. This suggests that horizontal mergers in a certain submarket could earlier be regarded as a deal breaker by antitrust authorities rather than vertical mergers. Next, concentration degrees in corridors might increase considerably due to a horizontal merger in a certain corridor submarket; however, network concentration degrees might still not be regarded as too high. Thus, a merger on a certain link or node does not need to have a large impact on network concentration degrees. If the analysis is lifted to the European level of package delivery, the acquisition of TNT by FedEx results in a reduction of the number of competitors from five to four, leading to a $CR4$ of 100%. However, national business competitors might also play roles, although not operating on the European level. Furthermore, concentration indices on OD pair and or corridor submarkets might depict different consequences of this merger.

4.3. Vertical Business Integration: Network Concentration

"Vertical merger" (or acquisition) means that different operators in different IFT submarkets merge. Suppose that a rail operator (capacity 10,000 TEUs) in link OA of our example decides to merge with a terminal operator (capacity 30,000 TEUs) in node A. What is the consequence of this merger on the degree of concentration inside the different IFT submarkets? There are two different possible situations, depending on the type of merger which we call "restricted" merger and "flexible" merger.

In a restricted merger, the two operators that merge are restricted to work with each other, and the extra capacity of the one that has more capacity could be sold to other operators in a competitive way. In a flexible merger, we have two different situations based on which operator is flexible. In the situation the operator with the higher capacity (restricted company) dedicates part of its capacity to the merged operator, whereas the operator with the lower capacity (flexible company) is not restricted to the dedicated capacity of the higher capacity operator (Flexible-L, Restricted-H). This means that it could still use the capacity of the other business operators. In the other situation (Flexible-H, Restricted-L), the business operator with lower capacity (restricted company) works only with the operator with higher capacity, but the business operator with higher capacity (flexible company) does not dedicate any capacity to the lower capacity operator but only gives it the priority to use its capacity.

In the restricted merger, the number of IFT chains is reduced, whereas in the flexible merger, the number of IFT chains is equal to the number of IFT chains before the merger, if the operator with the higher capacity is restricted (Flexible-L, Restricted-H). In the situation that only the business operator with the lower capacity is restricted (Flexible-H, Restricted-L), the number of IFT chains is reduced, which could have a larger effect on the concentration degree.

The degree of concentration inside different IFT submarkets that are affected by the merger is shown in Table 2. As can be seen, if the merger is a flexible merger in which the lower-capacity operator is flexible (the rail operator in our example), the concentration change will be marginal in corridors and O-D pair, because the number of IFT chains is fixed, whereas their flows distribute a little more smoothly.

If it is a restricted merger, or a flexible merger in which the higher capacity operator is flexible, the increase in the concentration indices is almost the same. In corridor OAD, concentration will be increased between 25% and 27% in terms of CR indices, and about 33% in terms of the HHI, which leads to a tight oligopoly market. In the corridor OABD, the concentration will be increased around 29% in terms of the CR indices and 33% in terms of the HHI, but it is still a loose oligopoly market. Like the horizontal merger, in the OD pair submarket, concentration in terms of the $CR1$, $CR2$, and $CR3$ indices does not change, and in terms of the $CR4$ and the HHI, there is a small increase because the three largest chains are inside the corridors OBD and OCD, which are not affected by the merger.

Results from the numerical example indicate that a vertical merger might have a lower impact on the concentration indices in corridors than horizontal mergers.

However, if we analyze the examples of EGS Rotterdam and the inland terminals in Brabant, it shows that in the end, it is also important how many competitors remain. In the case of EGS, one terminal operator has been said to provide advantageous handling conditions to barges operating in their EGS network over other barges. So although the other barges in theory do have alternative terminals in the port of Rotterdam to have their containers handled and also a sufficient number of competing barges is present, the actual behavior of ECT and its EGS network puts the other barges at a disadvantage because, in practice, they must have their containers handled at ECT. This means that vertical integration (IWW and terminal) does not need to have an effect of the concentration. However, it does have an impact when exclusiveness is introduced. In the case of the Brabant inland terminals cooperating to bundle inland waterway transport to and from Rotterdam, the competition on the inland waterway link Rotterdam Brabant is reduced, although there might be still enough competition on that particular inland waterway link. Furthermore, also rail and truck transport remain as transport options.

TABLE 2. Concentration indices Before and After the Vertical Merger

Related submarkets	Concentration indices	Values						
		Before	After			increase		
			Restricted	Flexible -H Restricted-L	Flexible-L Restricted-H	Restricted	Flexible-H Restricted-L	Flexible-L Restricted-H
Corridor OAD	CR1	16.1%	20.51%	20.00%	16.00%	27.64%	24.44%	-0.45%
	CR2	30.4%	38.46%	38.75%	30.00%	26.70%	27.65%	-1.19%
	CR3	44.6%	56.41%	56.25%	44.00%	26.36%	26.00%	-1.46%
	CR4	57.1%	71.79%	72.50%	56.00%	25.64%	26.88%	-2.04%

	HHI	1274	1702	1703	1280	33.68%	33.71%	0.5%
Corridor OABD	CR1	8%	10.53%	10.34%	8.11%	29.55%	27.32%	-0.21%
	CR2	16%	20.18%	20.26%	15.54%	29.12%	29.66%	-0.54%
	CR3	23%	29.82%	29.74%	22.97%	28.97%	28.61%	-0.66%
	CR4	30%	38.60%	38.79%	29.73%	28.65%	29.31%	-0.91%
	HHI	641	851	851	639	32.84%	32.83%	-0.23%
O-D pair	CR1	22%	22%	22%	22%	0.0%	0.0%	0.0%
	CR2	35%	35%	35%	35%	0.0%	0.0%	0.0%
	CR3	47%	47%	47%	47%	0.0%	0.0%	0.0%
	CR4	52%	53%	54%	52%	1.9%	3.8%	-3.1%
	HHI	805	868	869	804	7.8%	8.0%	-0.1%

5. CONCLUSIONS AND FUTURE RESEARCH

The IFT market is continuously evolving as a result of different regulatory policies and business practices adopted by different IFT operators. Although some business practices—like vertical integration and acquisition—potentially improve the IFT service, and the profit margin for some players, they might also influence the market structure and competition in the IFT network. Therefore, antitrust authorities proactively evaluate the decisions made by firms and the market outcomes that result. In a more reactive way, the antitrust authorities respond to complaints from transport market stakeholders. In both cases, a business practice might be restrained by antitrust authorities if it harms the consumer welfare by reducing the competition level in the market. The analysis of market structure of IFT service can be challenging though, primarily due to the multistage characteristic of the presented service. To investigate the impact of anticompetitive business practices on the market structure of IFT networks, we present a model—which is called IFTMS—in this paper. This model combines the market structures on IFT submarkets and extends them to the network level. IFTMS uses graph theory and defines distinct submarkets in an IFT network. These submarkets are represented as nodes (transshipments), links (main-haulages), and paths (corridors, and ODs). Each corridor has multiple IFT chains that include a sequence of nodes and links from an origin to a destination. The IFT chains in a corridor are organized by different competing intermodal operators to deliver an integrated IFT service to the final customer. As distinctive submarkets inside IFT network are defined, IFTMS applies a flow optimization model to assign the capacities to the IFT network players. Next, the concentration indices—like CR or HHI—for these IFT submarkets are calculated, and the market structure can be analyzed.

To illustrate the model, we studied an intermodal freight transport network. The application of IFTMS to this network helps us analyze the impact of business integration on the market concentration in the IFT market and its submarkets. In this case, the influence depends on the type of business integration (horizontal and vertical). Furthermore, the model indicates that mergers in the same submarket (horizontal) have larger impacts on market concentration in the broader market (e.g., corridors) than mergers in different submarkets (vertical). The findings of this model need to be interpreted in a conservative way in light of the methodological limitations and assumptions. These assumptions, i.e., simple business models for different operators, fair flow distribution in the network, or considering the barge and rail operators in a same main-haulage submarket, lead to a lower bound of market concentration in the IFT network.

The model developed in this paper could be used by antitrust authorities to investigate the anticompetitive practices in the IFT network. They can evaluate the effects of different business practices on competition and concentration in the IFT market and overall on the welfare of the society. It can also be used by business managers to examine the market implication of their business practices. The impact of anticompetitive business practices on the market structure of the IFT network depends on the chosen level of analysis. Next, different indicators that "represent" market structure and competition might react differently to the business integration.

The market structure of intermodal freight transport network as explored in this paper was already quite complicated under the assumptions made. Several possibilities for more complex situations are suitable for further research. First, more complex business models can be introduced such as more operators per submarket, different service offerings in different submarkets by the same business operator, different competitive powers per business operator, and inclusion of other types of business integration. Second, the presented network model can be extended by introducing for example, pre- and end-haulage and using other flow allocation methods. We can also make a differentiation between operators in different markets, considering the time and cost elements, in extending the IFTMS model.

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Annex A. Example of how, for instance, the CR1 is calculated for corridor OAD

No.	IFT chains	Weight of different IFT chains	Capacity of IFT chains
1	50-20-30-5-50	.2+.4+.6+.2+.2=1.6	(1.6/11.3)*15 (Assigned capacity of the corridor) = 2.1
2	50-10-10-10-50	.2+.2+.2+.4+.2=1.2	1.6
3	50-20-10-5-50	.2+.4+.2+.2+.2=1.2	1.6
4	50-20-10-10-50	.2+.4+.2+.4+.2=1.4	1.9
5	50-10-30-5-50	.2+.2+.6+.2+.2=1.4	1.9
6	50-10-30-10-50	.2+.2+.6+.4+.2=1.6	2.1
7	50-20-30-10-50	.2+.4+.6+.4+.2=1.8	2.5
8	50-10-10-5-50	.2+ .2 + .2+.2+.2 =1	1.3
		$\sum$ Weights = 11.3	

Least Capacity IFT chain

$$HHI = 1287; CR_1 = 17\%\,; \; CR_2 = 31\%; \; CR_3 = 45\%\,; \; CR_4 = 57\%$$

In the corridor OAD we have 3 nodes and 2 links. Considering different players inside each of these nodes and links, we have 8 (=1*2*2*2*1) possible IFT chains. we use the weighted average capacity method, and assume that all the players in different nodes and links in each IFT chain have the same weight. This means that the weight coefficient of players in each node or link is 0.2 , because each IFT chain in the corridor OAD has in total 5 elements (3 players in the nodes and 2 players on the links). We assign a weight of 1 to the IFT chain with the least available capacity (0.2+0.2+0.2+0.2+0.2). IFT chain with the least available capacity is the chain which is composed of operators with the least available capacity on the different links and in the nodes. In this example the IFT chain which is composed of operators with capacities (50,10,10,5,50) is the least available capacity chain (the last IFT chain in the Table). For the other IFT chains, we divide the capacities of different operators on the different links and in their nodes to the capacity of the operators in the least powerful chain, and then summarize the results based on the weights of the links or nodes of the corresponding chain in order to arrive to the weight of the chain. As you can see in the table, first the weight of different IFT chains is computed, and, based on these weights and the assigned capacity of the corridor (it is calculated in the O-D pair level), the capacity of the different chains is calculated. After that we can easily measure the CR and HHI indices having the capacity of each IFT chain.