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From road freight transport outsourcing chains to complex collaborative networks: a case study

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Abstract

Outsourcing processes in road freight transport constitute one of the most relevant operational features of this sector. However, the organisational articulation of these processes has not yet been studied in detail, due both to the opacity surrounding the collaborative relationships between companies and to their enormous complexity. Thus, this paper sets out, on the one hand, to identify the main subcontracting structures and information channels between companies and, on the other, to analyse the interdependent relationships between agents in road freight transport systems. In order to achieve these objectives, a case study was carried out using data from a survey of transport professionals in an area with a high concentration of logistics companies located on the border between Spain and France. The results reveal the enormous importance of outsourcing for the sector, where hierarchical structures and the selective transfer of information prevail over horizontal collaboration. They also show the existence of a complex network of collaborations, where some companies play central dynamising roles as opposed to other more peripheral roles.

Keywords: Transport outsourcing chains; survey; agents; complexity; knowledge transfer

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1. Introduction

Transport Outsourcing Chains (TOC) are contractual structures consisting of at least three actors, where one actor provides a service to another actor, who in turn provides a service to a third actor. Such structures are common in the road freight transport (RFT), where the first link is always the shipper and the last link is always the carrier. Between these two necessary actors, there can be several intermediaries of different rank and function. Moreover, these chains are highly hierarchical (Davidsson *et al*., 2008; Holmgren *et al*., 2010), as the scope of decision-making is reduced from one level to the next. Indeed, in transport systems, each of the agents involved has control over a part of the management (Batty *et al*.; 2012; Crooks *et al*., 2019), although they are not fully aware of the decision-making process of the rest (Roorda *et al*., 2010).

As such, interactions occur between these agents that affect the system, allowing it to evolve. In order to analyse their impact on the sector, numerous studies, many of them undertaken by public institutions, generally adopt a quantitative approach. However, a qualitative analysis based on a structural and operational perspective (Hesse & Rodrigue, 2004) is also necessary to understand the internal mechanisms of operation and interaction between transport agents. Moreover, in a context of increasing regulation of TOCs, it is crucial to study the relationships between transport companies not only as networks of information and knowledge exchange, but also as a product of spatial interaction. This research provides evidence of such interactions through a survey addressed to professionals involved in the operational management of RFT, carried out in the Donostialdea and Bidasoa-Beherea regions of Gipuzkoa (DABB area), on the Spanish-French border. Thus, the TRANSOPE (TRAnsport OPErations) survey is defined as an instrument for measuring collaboration between RFT companies from the point of view of the actors directly involved in decision-making: the logistics managers of RFT companies and the self-employed carriers.

The use of the survey method is common in the study of transport systems. We can find from surveys focusing on specific aspects such as the impact of multimodality (van Schinjdel & Dinwoodie, 2000; Karis & Dinwoodie, 2005) to macro surveys such as the 2004 French ECHO survey (Guilbault, 2008), dedicated to identifying different types of transport chains (Gavaud *et al*., 2011), through to surveys organised by EU public institutions, such as the Kraftfahrtbudesamt (KBA) in Germany (Friedrich *et al.*, 2003) or the Permanent Survey of Road Freight Transport (EPTMC) organised by the Spanish Ministry of Public Works. However, it is essential to look at the actors who make the operational decisions and to know how, where and why transport operations take place in order to understand the logic of how they work (Richardson *et al.*, 1995). This article is organised as follows: point 2 covers the methodological aspects of the research; point 3 details the results; and point 4 presents the conclusions.

2. Methods

2.1. The TRANSOPE survey

The survey was addressed to logistics managers of different RFT companies and self-employed carriers in the DABB area. According to the data provided by the Department of Mobility and Public Transport of the Provincial Council of Gipuzkoa for 2019, in 2019 these counties had 1129 companies engaged in the RFT sector, code 4941 according to the Spanish National Classification of Economic Activities (CNAE-2009). The sampling method was by convenience, i.e., non-random and non-probabilistic, provided by Fundación Guitrans Fundazioa, an association that represents the majority of transport service providers in Gipuzkoa. The sample size was 287 for a confidence level of 95% and a margin of error of 5%.

Two different questionnaires were then developed with the help of experts for each group of respondents. After evaluation, a pilot questionnaire was completed to correct errors and refine questions. Finally, the final web questionnaire was sent to a total of 351 RFT companies and self-employed carriers. The survey returned a total of 151 responses, with a final response rate of 52.61% of the sample size. This raised the margin of error to 7.43% for a confidence level of 95%. The collected data were first exported to .xlsx format to be processed and cleaned. The data sets corresponding to Likert scale type questions were subjected to reliability checks and comparison of means by means of hypothesis testing. The free statistical analysis software PSPP v.1.2.0 was used for this purpose. The results of the Likert scales were also represented by means of relative frequencies.

For the treatment of the results, different categories of transport service providers (TSP) were established within the two surveyed groups (Table 1). Thus, in the group of logistic managers we found three types of companies based on the type of activity: *i*) the transport agency (TA) is an intermediary company between shippers and carriers that does not have its own fleet; *ii*) the transport company (TC) has its own fleet to perform transport services, although it can also act as a transport agency; and, finally, *iii*) the freight forwarder (FF) performs customs clearance, storage of goods, cargo consolidation and transport agency functions and, like this, does not have its own fleet. On the other hand, self-employed carriers are categorised according to their working arrangements. Thus, we can divide carriers into regular self-employed carriers (RSC), i.e., those who work between 50% and 100% for a single customer, and non-regular self-employed carriers (nRSC), i.e., those who work less than 50% for a single customer.

Table 1. Categories of the surveyed companies.

	categories	number	% group	% total
FF	Freight Forwarders	5	10,4	3,3
TA	Transport Agencies	9	18,8	6,0
TC	Transport Companies	34	70,8	22,5
RSC	Regular Self-employed Carriers	87	84,5	57,6
nRSC	non-Regular Self-employed Carriers	16	15,5	10,6
	TOTAL	151	200	100

2.2. Agents and Transport Outsourcing Chains

The composition of TOCs and their internal communication mechanisms present different levels of complexity. This internal functioning is not fully known to the TOC participants themselves as this complexity increases, due to the confidentiality of the contractual relations between client and TSP. Despite this, in our study respondents rated the frequency with which they participate in eighteen possible TOC models that can be formed in a transport operation. Respondents rated from 1 to 5 the frequency with which they take part in each TOC model, with 1=never and 5=always. The first three models were rated only by transport operators. Three aspects were assessed in each model: *i*) how many and what type of actors take part in them, *ii*) how these actors communicate with each other, and *iii*) what place the respondent company occupies in the chain. In order to compare the participation in these models according to their complexity, a TOC Complexity Index (TOCci) was developed which relates these three aspects:

$$TOCci = \frac{n_{agents}}{\max_{agents}} \cdot \frac{n_{com}}{\max_{com}} \cdot \frac{s_{\text{int}}}{\max_{\text{int}}} \tag{1}$$

where n_{agents} is the number of agents in the TOC, $\max_{agents}$ is the maximal number of agents in the analysed TOCs, n_{com} is the number of bidirectional communications in the model, $\max_{com}$ is the maximum possible bidirectional communications in that model. Finally, regarding the position of the respondent firm in the chain s_{int} is the number of intermediaries up to the final carrier in a TOC and $\max_{int}$ is the maximum number of intermediaries up to the final carrier observed in a TOC.

Figure 1 shows the eighteen evaluated TOC models, where shippers (SHP) and recipients (RCP) are involved as necessary agents of the TOC. Models A, B and C present the lowest levels of complexity, where there are no intermediaries between the shipper and the direct customer. In contrast, models P, Q and R are the most complex, involving several intermediaries and information channels. Carriers (CAR) respondents are shown in red, while logistic managers of a transport service provider (TSP) are shown in blue.

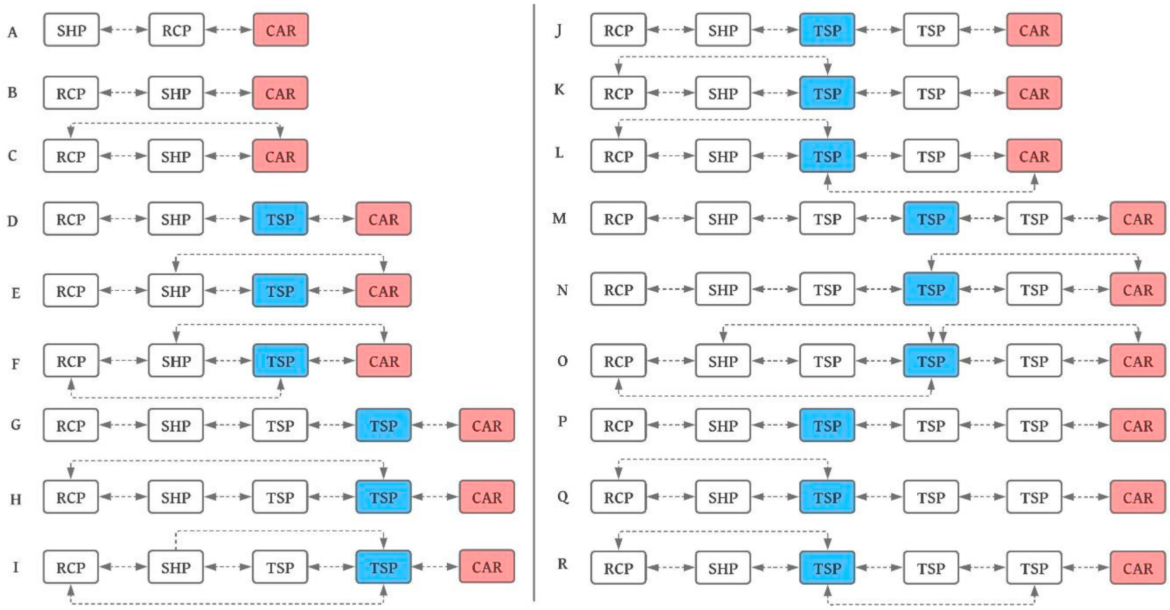

Fig. 1. Evaluated TOC models. Arrows indicate bidirectional communications between agents.

3. Results

3.1. Managing complexity in TOCs

Each type of agent reacts differently to each model, depending on its management and decision-making capabilities. Figure 2 relates the frequency of participation of each type of agent in the TOCs to their level of complexity. The trend line shows a decrease in frequency as the complexity of the models increases, which is applicable to all agents.

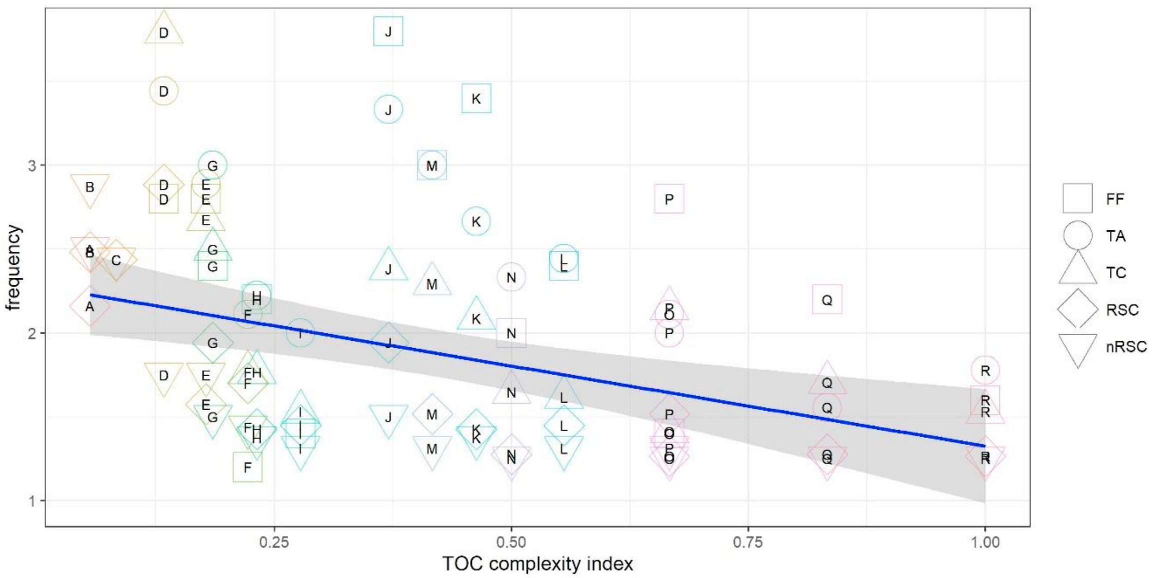

Fig. 2. Frequency of participation by type of agent according to the level of complexity of the TOC models.

However, the higher frequency of participation in more complex models by intermediaries (FF, TA and TC) compared to shippers (RSC and nRSC), who in principle prefer simpler models, stands out. One of the possible reasons for this could be the scarcity of information that these agents often have about the higher levels of the TOC in which they take part.

Thus, it is significant that there is no model shared by all the agents, although model G is the one that comes closest to this assumption. On the opposite, each agent seems to follow its own patterns of participation according to its rank in the TOC. In this sense, the results shown by agents with great decision-making capacity and operational control, such as Freight Forwarders (FF) and Transport Agencies (TA), are revealing. Finally, this diversity in the assessment of the different models places us in operational scenarios in which the interdependence between agents is due both to the difference in their interests and to their need for complementarity.

3.2. Hierarchical interdependence between agents

As we have seen, the participation of agents with different ranks and roles in road freight transport operations is a very frequent phenomenon. In order to analyse the interdependence relationships between these agents, the assignment of loads in different parts of the chain was studied. First, the logistic managers indicated, as TSPs, the origin of 10 loads in a typical week according to the type of customer. Next, the same logistic managers, this time as customers, distributed 10 loads among different types of TSPs. Finally, the self-employed carriers indicated the origin of 10 loads according to the type of customer. The responses of both groups introduced the involvement of other necessary actors in the transport chain, such as shippers (SHP) and recipients (RCP), as well as other types of companies specialised in warehousing (WAR) and freight exchanges on digital platforms (FEX). In addition, transport companies have their own vehicles and drivers (ODR) to cover their demands.

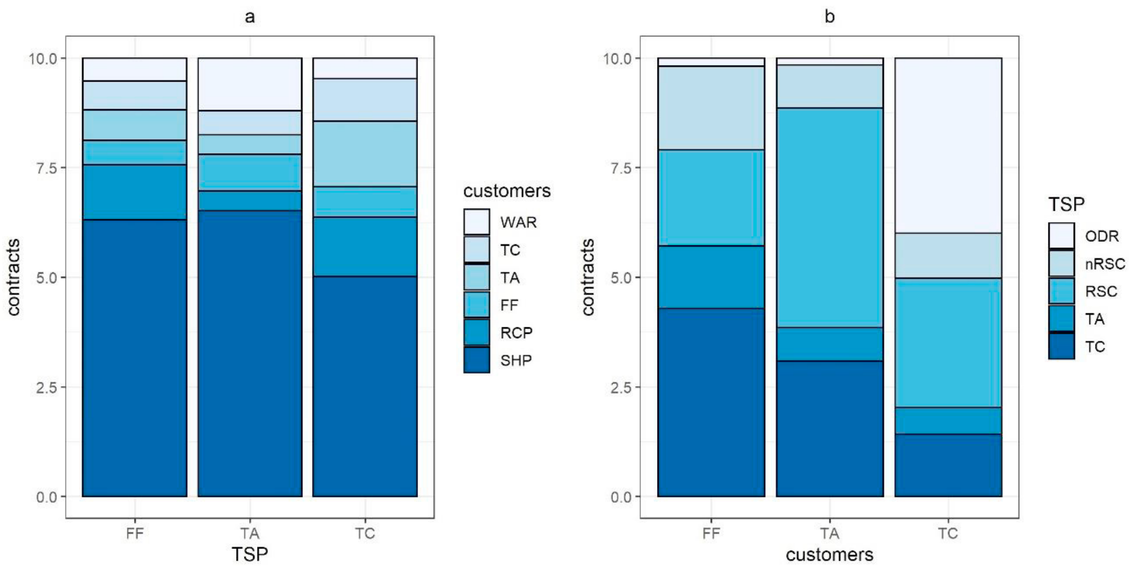

Fig. 3. Distribution of loads: (a) received by logistic managers according to type of customer and (b) assigned from logistic managers according to type of TSP.

The results show notable differences in the distribution of loads depending on the segment of the transport chain. For example, in the first segment (Fig. 3a), logistic managers receive their transport orders preferentially from direct customers (shippers and recipients), between 63% and 75%. However, the rest of the loads received come from contractual relationships between companies of the same rank (FF, TA and TC). This interdependence is even more revealing in the second part of the chain (fig. 3b), when these companies operate as customers by assigning the completion of their shipments to other agents. Indeed, the intervention of intermediaries between them and the final carriers (RSC and nRSC) is very evident in all three cases. Particularly remarkable are the high levels of outsourcing shown by the TCs (60% of shipments), despite having their own fleet.

With regard to the origin of the loads received by the final carriers (fig. 4), the results clearly indicate the existence of a third segment in the chain, as the dependence of RSC and nRSC on intermediary transport companies is 60% and 70% respectively, as opposed to the less frequent contractual links with direct customers (shippers and recipients). This fact reinforces the idea of a very complex, highly densified and locally interdependent system of operational relations between RFT actors.

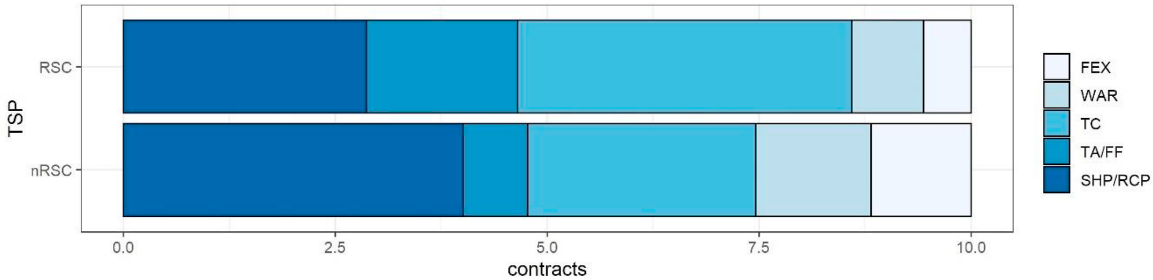

Fig. 4. Distribution of loads received by self-employed carriers according to the type of customer.

These interactions result in a weighted network (Ophsal *et al.*, 2008) of hierarchical outsourcing relationships between all agents involved in RFT operations. Fig. 5 depicts these relationships in a hierarchical graph. From left to right, the agents that start the transport operations (SHP, RCP and WAR) are shown first. These companies assign operational management to the central agents (FF, TA and TC), who have the largest number of input-output relationships. Thanks to this degree centrality, these agents lead the system and have privileged access to the knowledge generated by other professionals. Note that these agents also have self-directed arcs, as there is the possibility of load assignment within agents of the same category. Finally, at the bottom of the hierarchical structure are the effective transport providers (RSC, nRSC and ODR), who, despite their important role, have the lowest level of decision-making capacity in the system.

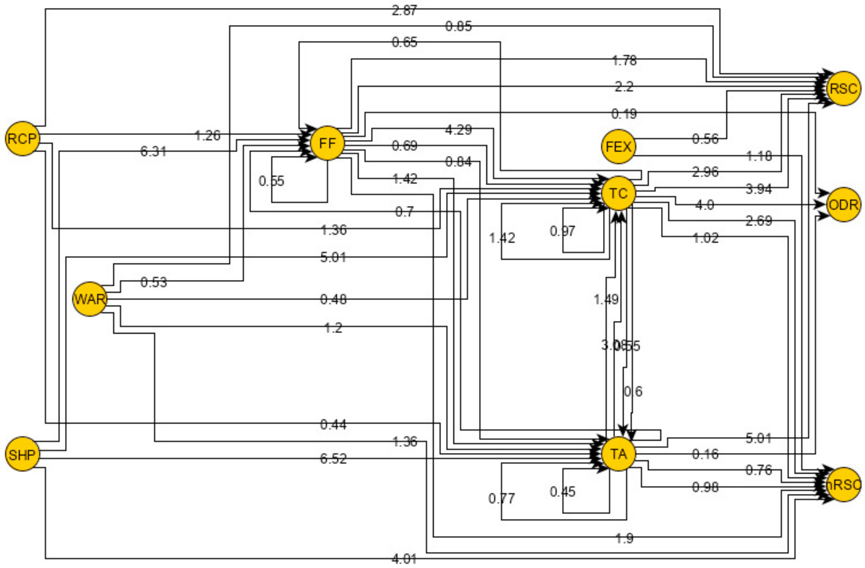

Fig. 5. Hierarchy of RFT systems according to the distribution of received and assigned loads.

The graph shows that TCs have the highest rank of degree centrality within the network, which is evidence of their operational capacity and their importance for the rest of the agents. Also, shippers supply shipments to the system mainly through several intermediary TSPs, who often interact with each other before assigning their shipments to final carriers. Finally, self-employed carriers, both regular and non-regular, show the highest degree of entry, demonstrating their wide accessibility to all types of companies, be they direct customers or intermediary TSPs. Evidence of their importance is provided by transport companies who, despite having their own fleet, use self-employed hauliers in 40% of shipments for reasons such as the lack of available drivers of their own or the existence of freight commitments with self-employed carriers.

3.3. Forming complex collaborative networks

In order to identify collaborative networks in a particular spatial environment and their actual scope, companies were asked about their collaboration with each other and with others in the environment. Specifically, logistics managers were asked to name between five and ten RFT partner companies, indicating whether these companies were customers or TSPs. Self-employed hauliers were asked to name between one and five RFT customers. Due to confidentiality and other types of errors, the valid response rate was 83% for logistic managers and 62% for self-employed carriers. The results are shown in figure 6, where each node is a real company and each arc is a collaborative relationship. Non-connected nodes correspond to invalid answers.

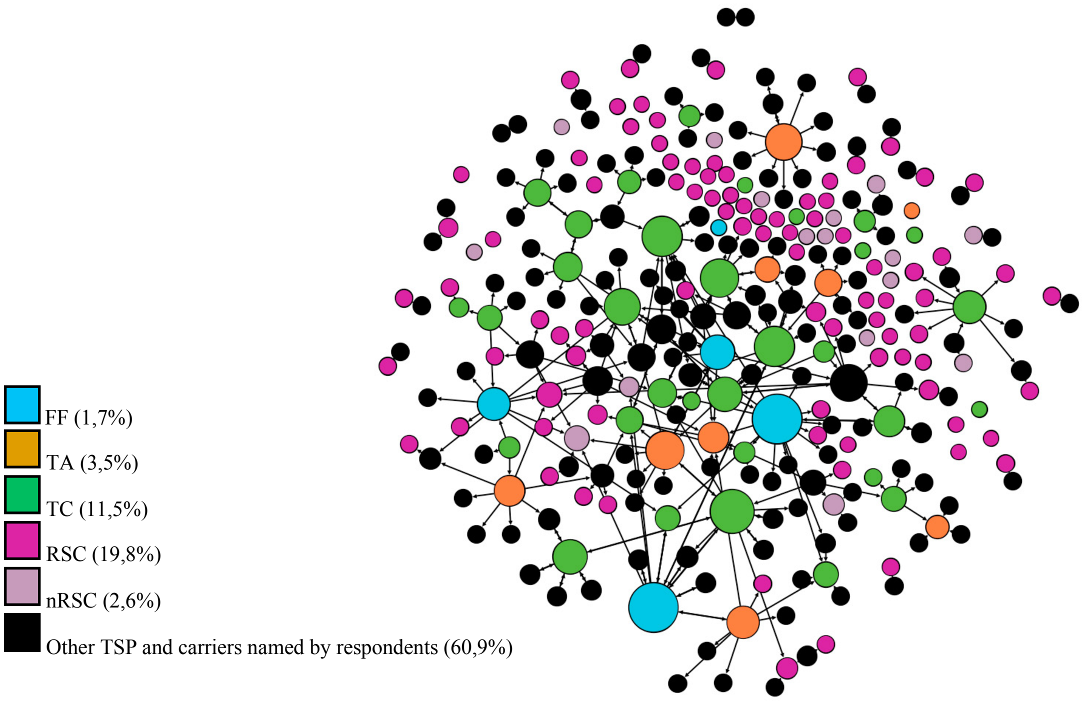

Fig. 6. Network of RFT companies in the DABB area.

Despite this, connectivity is considerable: 56.36% of all firms are connected to each other in a giant component and 83.5% of the inter-firm relationships occur in this giant component. The rest form small clusters or no clusters at all. The black nodes represent firms cited by respondents from the two groups and account for 60.9% of the total number of connected nodes.

The resulting network, consisting of 233 connected nodes and 291 arcs, provides the following general metrics: *i*) average degree $\overline{d}(G)$=1.275; *ii*) average path length or average distance between two firms $\overline{l}(G)$=4.831, i.e. less than

5 nodes average distance between one firm and any other in the network; *iii*) network diameter *dm(G)*=12, the maximum distance between any pair of nodes in the network. Concerning the organisational structure of the network, the weight of FFs and TCs is decisive because of the higher number of connections with self-employed carriers. The level of cohesion and connectivity shown by the network is remarkable, despite the fact that a significant number of respondents declined to provide the names of the TMC companies with which they collaborate.

4. Conclusions

The constant interactions between agents of different typology is the defining feature of RFT systems. Outsourcing chains at different levels of complexity facilitate these interactions and enable information and knowledge to flow between agents not necessarily related by contract, thanks to the high connectivity of the network. The study also shows that the complexity of TOCs is closely related to the preferences of higher-ranking firms within the system. Thus, agents with greater leadership are the ones who push for the formation of more complex structures as opposed to the preferences of self-employed carriers, who prefer more elementary chains. This gives them greater control over operational processes and the possibility of increasing their organisational learning by interacting with a larger number of professionals. In this sense, the case study presented in this paper is an RFT system made up of companies of different sizes and capacities for action, with different objectives and fields of activity, but all made up of individuals who make decisions on a daily basis and who voluntarily or involuntarily transfer information and knowledge to the network of which they are part. These transfers should be an object of study for further research.

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