European Research Studies Journal
Volume XXIII, Special Issue 1, 2020

pp. 476-487

A Comparative Analysis of Electronic Freight Exchanges in the United States and Europe with the Use of the Multiple Criteria Decision-Making Method "Promethee"

Submitted 23/09/20, 1st revision 11/10/20, 2nd revision 06/11/20, accepted 30/11/20

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Abstract:

Purpose: *The main purpose of this article is to conduct a comparative analysis of the electronic freight exchanges in the United States and in Europe by means of multiple criteria decision making (MCDM) method Promethee.*
Design/Methodology/Approach: *MCDM Promethee method with the use of secondary data based on industry and branch reports from Europe and the United States as well as available statistical data and the analysis of relevant literature. The article is addressed, both to EFEs providers as well as their users.*
Findings: *On the market of European and American open electronic freight exchanges there is a dispersed entity structure that promotes the occurrence of price competition. The differences, however, relate in particular to the number of users, geographic domination within the markets served, the period and nature of cooperation and the motives for its implementation, the integration of users' IT systems and the role of freight exchange operators in the construction and functioning of the supply chain.*
Practical Implications: *The indication of the fundamental differences between European and American exchanges, which comprise the area for further improvements. Research limitations: The analysis is based on secondary data. No possibility of obtaining primary data from the largest players on the market of electronic freight exchanges in Europe and the USA, which constitute confidential business information*
Originality/value: *tool development with the use of MCDM method for a comparative analysis of electronic freight exchanges. The tool can support electronic freight exchanges in the identification of strengths and weaknesses of their services as well as can be used in the process of formulation of their development strategies.*

Keywords: *Electronic freight exchange, multiple criteria decision making, Promethee, international comparative analysis.*

JEL classification: *M21, M15, O14.*
Paper Type: *Research study.*

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1. Introduction

Electronic freight exchanges (EFE) are one of the most dynamically developing e-logistics tools. EFEs are mainly focused on road transport and are widely used mainly in Europe and North America, which is due to the specificity of these markets. It relates for example to the significant fragmentation of the market, where a large number of logistics service providers operate, as well as to the availability of developed road transport infrastructure and warehouses. There is also a noticeable high level of commoditization of services, which results in an increase in demand for transport and forwarding services. In the European Union countries, the Internet transactions comprise 10 to 20% of the tonnage of transported cargo, while in the United States this percentage ranges from 15 to 20% (Baron *et al.*, 2017).

In Europe, the first EFE was the French *Teleroute*, which in 1985 commercialized the service supporting transactions between bidders of transport and forwarding services. Before *Teleroute* became one of the leaders of EFE in Europe, in the pre-Internet period, it offered traditional mediation between shippers, forwarders and carriers using a fax to send information previously collected. In contrast, in the United States, one of the precursors of EFE was *Truckstop*, founded the 1995, which still operates gathering around 200,000 users.

Thanks to a full access to modern technology and ICT solutions, EFEs offer an ever-wider range of services apart from road transport. Amongst them it can be distinguished: factoring, educational services, integration with users' IT systems, legal services, or the development of autonomous vehicles. These services differentiate EFEs on the American and European markets.

Thus, the main purpose of this article is to conduct a comparative analysis of the EFEs in the United States and in Europe in terms of their scope and innovative services. The article is addressed, both to EFEs providers as well as their users. It is a useful ranking for providers who want to improve and expand the range of services offered. In addition, the ranking may be relevant for current and especially potential users who are wondering which EFE to use. To conduct a comparative analysis a multiple-criteria decision making method (MCDM) Promethee has been applied.

The structure of the paper is as follows: in the second section a relevant literature review has been conducted, while in the third section research method and procedure has been introduced. The fourth section presents study results, and the last section concludes the paper.

2. Electronic Freight Exchange – Literature Review

In the literature there is a lack of consistency in the terminology used on the freight forwarding and logistics services market in the context of existing EFEs. Among commonly used terms in scientific publications as well as outside EFE, related terms

such as "*digital freight platforms*" (Baron *et al.,* 2017), "*e-freight marketplaces*" (Hassall and Welsh, 2014), "*online freight exchange*", "*electronic marketplace*" (Electronic Logistics Marketplaces Research Report, 2008), "*transportation electronic market*" (Marasco, 2004), "*logistics marketplace platforms*" (Hofmann and Osterwalder, 2017), "*freight brokers*" (Rafter, 2017), "*load board*" (RTS Financial, 2019), "*Internet freight exchange*" (Davies, Mason and Lalwani, 2007), are applied.

The EFE is an intermediary service with the use of internet technology, which supports communication and transactions between TSL companies and shippers ordering loads to be transported and other supporting services (Witkowski, 2019). Websites, instant messaging, and mobile applications that replace widely used mailing lists, faxes or offline databases are commonly used in B2B relations. This form of e-commerce is systematically evolving by expanding the package of offered services. On the path of successive implementation of increasingly modernized modules and the integration of IT systems, the evolution towards electronic logistic platforms (ELP) is observed. They offer a comprehensive package of services, which thanks to integration with users' IT systems support their logistics processes and serve to build long-term relationships between participants in the supply chains (Witkowski, 2019).

In connection with the above, it can be assumed that EFEs are evolving according to the following steps (Baron *et al.,* 2017):

- EFE 1.0, 1.5, which is understood as a traditional EFE on the transport-forwarding and logistics market based on B2B relations. The expanding packages of offered services contribute to the modernization of these platforms by introducing state-of the art modules and solutions. EFE 1.0 and 1.5 mainly focus on road transport using the services of transport companies. The consolidation on the market is noticeable regarding EFE 1.0 and 1.5, as well as the creation of strategic alliances.
- EFE 2.0, which apart from features of EFE 1.0 and 1.5 is characterized by the use of advanced algorithms to calculate and optimize activities, e.g. based on historical data and forecasts, or using dynamic analyzes at the network level to optimize transport routes. The so-called *e-forwarders* should also be included to EFE 2.0. Within EFE 2.0, the scale of activities exceeds the digitization itself.
- ELP (or Carrier integrators), which enable the automation of the transport management system (integration of *Transport Management System* modules, including *Time Slot Management*) and integrate the IT systems of the exchange users. ELP are based on virtualization using cloud solutions integrating ERP systems.

A wide scope of issues regarding EFE are presented in literature. Bierwirth, Schneider, and Kopfer (2002) suggested that in the beginning of 21st century EFE

was rather experimental than common in terms of the electronic marketplace. However, the potential and importance of the so-called e-business technology focusing on the forwarder trade cost reduction (and freight forwarding industry in general) has been noticed in the literature (Liu, Tao, and Yin, 2006). The advantages of a new solution were also noticed by larger logistics companies, which turned toward modern information and communication technology (ICT) (Davies, Mason, and Lalwani, 2007).

In the literature subject many positive aspects of EFEs are discussed. The reduction of costs is not the only scope of EFE. For instance, Tiwari and Singh (2011) presented the impacts of the EFEs on environment. The web-based technologies are recognized mainly as positive due to the clean and environmentally caring economy. Tánczos and Török (2008) analyzed the impact of CO_2 emissions from transport sector on environment, while UNCTAD (2015) diagnosed a huge negative environmental impact of oil consumption, including air pollution and GHG emissions. Tiwari and Singh (2011) as well as UNCTAD (2015) concluded that reducing the number of inefficient vehicle trips (such as empty runs) is necessary to reduce the level of carbon emissions. The discussion on EFEs relevance for transportation industry were also provided by Caplice (2007), while Grzybowska, Kovacs and Lenart (2013) discussed the IT technical approach of cloud supply chains.

Researchers described the new type of hybrid cloud supply chain: electronic freight and warehouse exchanges. Subsequently, there are a number of articles related to the communication systems, e.g.: the analysis of the problem of decision making for transporters in EFE (Mallick, Sarkar, and Mitra, 2017), the semantic modeling of information for EFE (Luncean and Badica, 2014), the diagnosis of the role of information technology in agent-intermediated electronic market (Nault and Dexter, 2016), the presentation of a general architecture of EFE system (Leon and Badica, 2017), optimization using agents and constraints (Badica *et al.,* 2017) or using telematic systems in road transport companies from the perspective of its managers (Osińska and Zalewski, 2020).

Furthermore, an in-depth investigation of network relationships of EFE's members has been presented by Fuks, Kawa and Pieranski (2015). A new proposal of an agent-based freight exchange that is an automated and interconnected marketplace eliminating problems related to intermediaries has been prepared by Fohring and Zelewski (2015). Additionally, the proposal fits the multimodal freight transport.

Wozniak *et al.* (2018) analyzed the selected available EFEs and proposed the standardization of EFEs' activities. However, there is no publication which applied MCDM methods to conduct a comparative analysis of EFEs activities.

3. Research Procedure and Analyzed Markets

3.1 Research Procedure

In this paper, four stages of research procedure were implemented.

The first stage (i) refers to the development of the research methodology on the basis of literature review in the area of EFE. The authors have investigated articles and reports published in Web of Science database as well as industry and branch reports from Europe and the United States.

The second stage (ii) refers to the data collection. The research was conducted between 2019 and 2020. The authors have thoroughly analyzed secondary data from industry and branch reports and investigated EFEs websites. As a result of the research, five EFEs from the United States and four EFEs from Europe have been distinguished (listed in alphabetical order): *123Loadboard*, *Convoy*, *DAT*, *Teleroute*, *Timo.com*, *Trans.eu*, *Truckstop.com*, *Uber Freight*, *Wtransnet*. The main factor for the EFEs' selection was the number of users or the number of daily transactions. Therefore, the study is focused only on well-established leaders within the analyzed markets. Numerous local and late coming EFEs in Europe and US were not considered.

The third stage (iii) refers to the development of the family of criteria. The criteria have been defined on the basis of authors' expertise, analysis of discussed topics on EFEs in the subject literature (Caplice, 2007; Grzybowska, Kovacs and Lenart, 2013; Mallick, Sarkar and Mitra, 2017; Luncean and Badica, 2014; Nault and Dexter, 2016; Badica *et al.*, 2017) and accessibility to the data. In this study, two criteria were eliminated from further analysis because of the same scores in all EFEs.

The fourth stage (iv) refers to the application of the multiple criteria method Promethee. This method was used to compare EFEs in terms of their scope and innovative services, and selecting EFEs with a high, medium, and low degree of advancement in the characterized areas.

The Promethee method has been conducted according to the following steps (Brans, Mareschal and Vincke, 1986; Abu-Taleb and Mareschal, 1995; Kiba-Janiak and Witkowski, 2019):

1. Defining clusters, the groups of criteria and criteria (C) for EFEs.
2. Defining functions and preference thresholds. Linear functions were adopted for all criteria, the thresholds of incomparability (indistinguishability) Q and preferences P were defined for each criterion.
3. The comparison of individual variants in pairs. The calculation of the multi-criteria preference index π at first:

$$\pi(a,b) = \sum_{j-1}^{c} w_j \times P_j\,(a,b) \tag{1}$$

where $w_j > 0$ is the normalized weight assigned to the criterion C_j (the more important f_j, the larger w_j); $P_j\,(a, b)$ is the value of the preference function for the criterion C_j, when the variant a is compared with the variant b.

The value of index ranges from 0 to 1. It describes the degree to which the variant a is preferred in relation to the variant b, considering the criteria and normalized weights. Thus:

$\pi(a,b) \approx 0$ means that there is a slight prevalence of variant a over b. (2)

$\pi(a,b) \approx 1$ means that there is a significant prevalence of variant a over b. (3)

4. Ranking obtained using Visual PROMETHEE software through negative and positive preference flows. Their calculation is essential for the consolidation of the results from step three. As a consequence, the ranking from the best to the worst is obtained. Three different preference flows are calculated in the study: Phi+ (φ+): positive flow (or leaving flow), which measures how much variant a is preferred over another $n - 1$; Phi-(φ^-): negative flow (or entering flow), which measures how many variants $n-1$ are more preferred in relation to the variant a; Phi (φ): net flow, which is the balance between positive and negative flows. It is obtained by aggregating positive and negative flows of a given variant into one final result. $\varphi\,(a)$ can be positive or negative. The higher the score, the better the position of the given variant in the ranking. The two types of rankings are obtained as a result of computer simulation: a partial ranking (Promethee 1) and a complete ranking (Promethee 2). The first one presents the negative and positive flows, while the second one presents the complete ranking of the net flows.

3.2 Family of Criteria

To conduct the comparative analysis, the authors develop the family of 15 criteria. The criteria have been classified into 6 groups, such as: fee for carriers and shippers (criterion C1), real-time monitoring (criteria: C2.1, C2.2), optimization (C3.1, C3.2, C3.3), information accessibility (C4.1, C4.2), level of safety (C5.1, C5.2), innovative additional services (C6.1, C6.2, C6.3, C6.4, C6.5). The three groups of criteria (C2, C3 and C4) include the criteria which are related to the utilization of IT technology. Criterion C1 and C5 consist of criteria related to safety and the level of fee. The last group of criteria C6 include innovative services and products offered by EFE (e.g. factoring, law and educational services, multi-language service, etc.). Most criteria tend to maximum (the higher score the better value). Only one criterion C1 tends to minimum (the lower score the better value). All criteria have been presented in Table 1. The criteria for evaluation have been selected based on the existing data.

***Table 1.** Characteristics of the criteria used for evaluating of EFEs*

Area	Name of criterion	Description of a criterion
C1	C1 – fee for carriers and shippers [min*]	(1) Total free; (2) The access is available without subscription fee but with micropayments for additional services; (3) Differentiation access prices depending on additional features; (4) Differentiation access prices for carriers, shippers and forwarders depending on additional features; (5) Differentiation access prices for carriers, shippers and forwarders, and micropayments for additional services; (6) Full access with differentiation access prices for carriers, shippers and forwarders; (7) Full access with micropayments for additional services; (8) Full access in one price.
C2 – real-time monitoring	C2.1 – GPS monitoring system [max**]	(1) There is no GPS monitoring system in the particular EFE; (2) The GPS monitoring system operates within EFE.
	C2.2 – market situation monitoring system [max]	(1) There is no market situation monitoring system in the particular EFE; (2) The market situation monitoring system operates within EFE.
C3 – optimization	C3.1 – cost optimization [max]	(1) EFE has not implemented any kind of algorithms for cost reduction; (2) EFE has implemented algorithms for cost reduction.
	C3.2 – driver's time management services [max]	(1) Non-existence of the service; (2) Existence of the service.
	C3.3 – routing and scheduling optimization [max]	(1) EFE has not implemented any kind of algorithms for delivery times; (2) EFE has implemented algorithms for delivery times.
C4 – information accessibility	C4.1 – access to information via web-based EFE system [max]	(1) General information about EFE; (2) EFE overview with features characteristics; (3) Education materials.
	C4.2 – integration with users' IT systems [max]	(1) EFE is not integrated with users' IT systems in any way; (2) EFE has implemented solution in order to integrate with users' IT systems; (3) EFE is integrated with several users' IT systems; (4) EFE is fully integrated with users' IT systems.
C5 – level of safety	C5.1 – insurance services [max]	(1) Standard security level; (2) Transaction review system with or without company profile; (3) The certification of users.
	C5.2 – conditions of entry [max]	(1) Low conditions of entry (up to company entry in the National Court Register); (2) Medium conditions of entry (entry in the National Court Register, civil liability insurance); (3) High conditions of entry (entry in the National Court Register, civil liability insurance, carrier's license/certificate of professional competence).
C6 – innovative additional services	C6.1 – law services [max]	(1) Non-existence of the service; (2) Existence of the service.
	C6.2 – factoring services [max]	(1) Non-existence of the service; (2) Existence of the service.
	C6.3 – development of autonomous vehicles [max]	(1) Autonomous vehicles are not a part of EFEs strategy; (2) There is willingness to develop autonomous vehicles; (3) EFE is investing in autonomous vehicles openly.
	C6.4 – education and job services [max]	(1) Non-existence of the service; (2) Existence of the service.
	C6.5 – multi-language service [max]	(1) Non-existence of the service; (2) Existence of the service.

***Note:** *min – criterion tends to minimum, **max – criterion tends to maximum*

***Source**: Own elaboration.*

3.3 Characteristic of EFEs in the United States and in Europe

The comparative analysis of EFEs in Europe and in the USA indicates numerous similarities. In particular, this applies to the dispersed entity structure on the open EFEs market, which promotes the existence of price competition. It is estimated that both in the US and in Europe EFE acts as an intermediary in transactions corresponding to nearly 20% of the tonnage of transported cargo. Aiming at increasing market shares and avoiding price competition, the leaders of EFEs are forced to constantly expand the offered package of support services, increase transaction security, and integrate their products with the IT systems of their users. In both markets there are new players offering free transaction mediation and a micropayment system for using dedicated insurance, factoring, leasing, and other services.

However, due to the scale of the European market and restrictions on obtaining the right number of users, which would allow exceeding the break-even point, such initiatives in Europe are not effective. The situation is different in the US market, where it is forecasted that the EFE *Convoy* created in 2015 and *Uber Freight*, operating from 2017, have a chance to gain a dominant market position. Other differences in the functioning of EFE in Europe and the United States are presented in Table 2.

Table 2. *Differences in American and European EFE's*

Feature	European EFE's	American EFE's
Percentage of tonnage of transported loads	10-20%	15-20%
Number of users	Up to about 100,000	Up to about 1 million
The possibility of expansion	Currently: Europe Expansion: Euro-Asia, handling services along the New Silk Road	Currently: the United States Expansion: Canada
Geographical domination	In the country of origin and neighboring countries	None (the service of the entire market)
Duration and nature of cooperation	Short with the prevalence of one-off transactions. A noticeable need for a strategic shift towards evolution in ELP	Short with the prevalence of one-off transactions. Progressive uberization
The main theme of cooperation	Reduction of transport costs, improvement of the quality of logistics services	Reduction of transport costs, use of economies of scale
Integration with IT systems	Common in the case of groups of shippers and logistic companies	Common also for individual shippers and carriers
The role of the exchange operator in the construction and functioning of the supply chain	Active	Passive Active in the case of uberization of transport services
Subscription fee	Indispensable for the largest EFE in Europe	The largest EFE also available without a subscription fee: *Convoy, Uber Freight*

Source*: Own elaboration.*

4. Study Results

The results obtained from the Promethee MCDM method presents the final ranking of EFEs selected to the research. As a result of the simulation the following the best to the worst sequence was identified: the highest level of EFE's scope and innovative services is presented by the EFE *Trans.eu*, while the next positions are occupied by *Uber Freight*, and then *Timo.com* and *Teleroute*.

In the comparative analysis the number of particular EFE's users were not included due to different standards of gathering such data. Therefore, EFEs with the highest level of users do not have the highest position in the presented ranking. In the research the focus was put on the IT solutions that support users and on the innovative services that go beyond standard EFE's services. Thus, the first place in ranking is occupied by the EFE *Trans.eu* with φ=0,3113 that offers, among others, integration with users' IT systems, the certification of users and providing education materials. This EFE exceeds its competitors in terms of the innovative solutions.

On the second place there is *Uber Freight* with φ=0,1366. This EFE owes its position to being fee-free for carriers and shippers as well as to the development of autonomous vehicles and optimization. It shows that this young EFE is expanding very dynamically, especially in the field of developing innovative solutions which also respond to environmental problems. In the next group are the oldest European EFEs: *Timo.com* with φ=0,0989 due to the integration with users' IT systems and real-time monitoring, and *Teleroute* with φ=0,0826 due to providing education materials. These two EFEs have a very good position on the market and a good quality of traditional transport services, however, it seems that they do not extend their services in an innovative manner as it is in the case of *Trans.eu* and *Uber Freight*. In dynamically developing market these EFEs should consider expanding their activity with implementing more innovative services. The Promethee method results are presented in Table 3.

Table 3. *Computer simulation results with the use of the Promethee method*

Rank	EFE	Phi	Phi+	Phi-
1	*Trans.eu*	0,3113	0,4123	0,101
2	*Uber Freight*	0,1366	0,2686	0,132
3	*Timo.com*	0,0989	0,2882	0,1892
4	*Teleroute*	0,0826	0,2051	0,1225
5	*Wtransnet*	-0,0796	0,1176	0,1971
6	*Convoy*	-0,0908	0,1274	0,2181
7	*123Loadboard*	-0,1089	0,08	0,1889
8	*Truckstop.com*	-0,1356	0,0831	0,2187
9	*DAT*	-0,2147	0,0468	0,2615

Source: *Own elaboration.*

5. Conclusions

The main purpose of this manuscript was to conduct a comparative analysis of the EFEs in the United States and in Europe in terms of their scope and innovative services. In order to conduct this analysis a multiple criteria decision-making method Promethee has been conducted. This method allows not only to make a general ranking, but also shows results for specific areas. The graphic capabilities of this method also allow to present the relations between various alternatives. According to the authors, this is one of the most extensive MCDM methods, enabling comprehensive analysis of the research problem.

The comparative analysis of the EFEs in the United States and in Europe in terms of their scope and innovative services allows to diagnose the following conclusions:

- on the top of the ranking were placed EFEs that extended their traditional services into innovative solutions that may support customers in other areas than traditional transport services;
- the older EFEs tend to focus on traditional transport services rather than innovative services, accordingly the late comers to the market are more likely to implement solution that may be characterized as innovative;
- dynamically increasing freight market requires new modern solutions which should be implemented in order to increase the competitiveness of the EFE;
- the largest players on the US EFE market support a larger number of users than in the case of European EFEs, and also operate throughout the geographical area of the market, while European EFEs dominate only in the country of origin and neighboring countries;
- progressive uberization on the US EFE market is noticeable;
- the largest EFEs in Europe necessarily require a subscription fee, while two leading US EFEs offer access without such a fee;
- the European EFEs tend to implement innovative services, while American EFEs concentrate on traditional transport services and more emphasis is placed on free of charge access, therefore the role of the exchange operator in USA is passive apart from the EFEs with progressive uberization of services – the situation on the European market is different due to the active role of the exchange operator.

The authors are aware that conducted comparative analysis refers only to the data included in the research. Due to the limitations in the access to primary data this analysis is not complete. However, the tool developed by the authors with the use of multiple criteria decision-making methods can be useful for EFEs for the purpose of competitive analyses. For further research, the authors plan to extend the analysis of other EFEs as well as to conduct more in-depth study.

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