THE IMPACT OF COVID-19 ON INTERMODAL FREIGHT TRANSPORT: AN EX-ANTE AND EX-POST ANALYSIS

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ABSTRACT

It is well known that one of the most efficient ways of moving goods is the combination of two freight transport systems, rail and road. The purpose of this study is to evaluate factors that affect the competitiveness of intermodal rail-road transport (IRRT). Previous research has focused on the definition of a multi-criteria framework to identify and prioritize the determining factors. However, the assessments have been done before the coronavirus pandemic, but after the quarantine and post-quarantine period of the virus, the prioritization of these criteria has definitely changed in the view of experts and customers. The appearance of a drastic change in some of the influencing factors during this period, e.g. political decisions that affect regulation and operations, as well as changes in technology and the use of infrastructure, have make it necessary to reevaluate the IRRT.

In order to carry out this evaluation, a combination of two methods has been performed: (i) Laboratory-based hierarchical structure to test and evaluate the gray decision (gray-DEMATEL), and (ii) Network Analysis Process (ANP) to carry out the evaluation of the IRRT system in Spain. As a result of this work, an ex- ante and ex- post analysis of the evaluation of the criteria is shown, with respect to the evaluations made by decision makers during the post-pandemic.

This work shows how the importance and necessity of the criteria have changed as the world has changed due to Covid-19, and what factors have changed the priorities of customers, experts and operators based on the current situation. This research also provides theoretical and managerial insights for policy makers and researchers in this field.

1. INTRODUCTION

An intermodal or multi-mode transport system is a combination of two or more modes of transport (Steadieseifi et al., 2014). For achieving the most economical, efficient, and environmentally friendly way to transport goods and passengers to a destination (Kumar& Anbanandam, 2020).

To minimize the environmental impact of transportation, switching from roads to more sustainable modes such as railways and waterways is required (Eng-Larsson & Kohn, 2012). It is necessary to identify inter-model rail barriers (IRR) to transfer part of the road transport to rail transport (Tsamboulas et al., 2007).

Roso (2013) to reducing the negative impact on the environment and social activities, the government usually tries to change the mode from single-model transportation to inter-model transportation of goods. Therefore, managers must identify organizational challenges to increase the prosperity of inter-model transportation services and face the complexity of the supply chain network (Monios & Bergqvist, 2016).

The analyze of barriers in several dimensions such as economic, technical, environmental, social, and political is needed to develop an inter-model freight system (Tsamboulas et al., 2007). In this sense, Kumar & Anbanandam (2020) identify IRR criteria in various decision dimensions (policy, operating regulations, technology and infrastructure, knowledge, organization, and government).

For this purpose, the grey-DEMATEL method (Gabus & Fontela, 1972) is used to identify the mutual relationships of criteria and handle dependencies among criteria. Its dimensions are taken by ANP (Saaty, 1996). The DEMATEL technique is introduced and combined with ANP in can make up for the equal weighting assumption of ANP (Büyükeozkan & Güleryüz, 2016). Kumaer & Anbanandam (2020) develope an evaluation framework from multiple user perspectives and perform an integration of grey theory-based decision-making trial and evaluation laboratory (grey-DEMATEL) and Analytic Network Process (ANP).

While at the end of December 2019, China reported several cases of an acute respiratory infection in Wuhan City, Hubei Province, China. The World Health Organization (WHO) named the previously unknown virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and called the disease caused by the virus coronavirus disease (COVID-19) (WHO 2020).

This virus has disrupted global production lines, supply chains, international trade, and the world's maritime and aviation networks. Araz et al. (2020) emphasize that the COVID-19 outbreak constituted one of the crucial disruptions experienced during the half-century, “breaking many global supply chains.” (Other authors,e.g Dolgui, Ivanov& Sokolov 2020; Golan et al.,2020; Haren&Simchi-Levi 2020; Hobbs, 2020; Linton &Vakil, 2020; Remko, 2020, (consider theCOVID-19) as a global catastrophe that affects human life and economic activities such as production operations, supply chain and logistics, and several other sectors.

The constraints of this epidemic lead to labor shortages, followed by logistical disruptions, and ultimately supply shocks to the supply chain (Hobbs 2020). The current global supply chain has weaknesses that have led to a loss of revenue, demand, and supply shortages in the

Covid-19 situation (Linton & Vakil, 2020). Following the various destructive effects of this epidemic, the prioritization and impact of intermodal transportation indicators have also been affected by this situation.

This article aims to identify the different types of intermodal transportation criteria which are related to geographical location by reviewing the papers. We then turn to the changes resulting from the ranking of these clear criteria before and after the coronavirus epidemic. To analyze criteria interactions. we use the combined Gray Theory and Decision Making Test and Evaluation Laboratory (DEMATEL) method, e.g., Gray-DEMATEL.

The rest of the paper is structured as follows. Section 2 presents the background of the study. Section 3 shows the method that has been applied. Section 4 analyses the main results, and finally, Section 5 concludes the main findings.

2. BACKGROUND

2.1 Framework

Identifying the influencing factors to analyze the relationship between multiple criteria and appropriate measures to promote them has broadly been addressed in literature. In this sense, the most common factors for selection decisions are economic (Eng-Larsson&Kohn, 2012). To reduce the negative impact of road transportation, some modal shift measures, such as the promotion of intermodal freight transport, mitigation of intermodal freight transportation adoption barriers, and improving the utilization of rail and water-based transport systems have been adopted (McKinnon et al., 2015).

Most freight industries in developing countries face many challenges in obtaining real-time data on environmental, social, legal, and organizational factors for intermodal services.
For this purpose, a literature review and expert opinions are carried out to identify the relevant factors. Next, they are divided into five main dimensions: Operational, Technology, and infrastructure of organizational knowledge of government policy and regulations (Kumar & Anbanandam, 2020).

Kumar & Anbanandam (2020) illustrated operational indicators to relate to the factors that hinder the supply chain and the logistics performance of the inter-model transport system. The author concluded that freight shippers have not adopted intermodal services for short hauling to the additional cost of pre and post-haulage. Road freight is often the priority of transportation because inter-model freight transport does not exist in the underdeveloped rail transport infrastructure and hinders the popularity of inter-model freight (Lindholm & Behrends, 2012). Intermodal rail transport infrastructure factors point to the lack of physical infrastructure and the technology available for the intermodal transport system (Kumar & Anbanandam, 2020). Most of the criteria for purchasing transportation services focus on the economic aspect and quality of business delivery, while the environmental side is less

advertised (Elbert & Seikowsky, 2017; Lammgård, 2012). Knowledge is one of the most critical factors to improve the organization's competitiveness by developing products, processes, and people (Cheng et al., 2008). Organizational barriers refer to the organizational structure of the organization and its relationship with other organizations. In the age of digitalization and information technology, sharing shipping information with other companies is an essential criterion for choosing a mode (Truschkin & Elbert, 2013). The lack of government policies and environmental regulation hinders the modal shift (Islam & Zunder, 2014). Monios & Bergqvist (2016) concluded that a poor modal balance between rail and road mode reduces the adoption of intermodal services. Policy Makers to improve the intermodal services, might assess incentives that enable the use of intermodal services (Elbert & Seikowsky, 2017; Tsamboulas et al., 2007).

2.2 DEMATEL & ANP method

Multiple criteria decision-making (MCDM) methods are prevalent methods to deal with the complicated problems, including conflicting objectives, hierarchical structure, and involvement of various stakeholders (Demirel et al., 2010).

The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is used to find the cause-effect interdependencies of the factors and measure in relation values. The relative importance is measured by the prominence value of factors (Geolcük & Baykasoɬ, 2016). The priority weight of factors cannot be determined by the DEMATEL method; however, ANP method help to compute the structural dependency of the decision problem (Büyükeozkan et al., 2017; Büyükeozkan & Çifçi, 2012). The integration of DEMATEL with the ANP method reduces the complexity of the problem and helps to identify the global influence strength of factor (Büyükeozkan & Güleryüz, 2016). In the DANP method, the DEMATEL method is used to collect the data, identify interrelationships, and measure interdependences. In contrast, the ANP method is used to drive the unweighted supermatrix, weighted supermatrix, and the limiting matrix for computing the influential weights of the factors (Ju-Long, 1982). This method can combine grey's theory with different MCDM methods to improve the accuracy of the decision-making process (Xia et al., 2015). The benefit of the grey systems idea over the fuzzy approach is that it does not need any robust fuzzy membership function (Xia et al., 2015).

2.3 Impact of Covid-19 on the supply chain

According to World Trade Organization (WTO) figures, the worldwide economy gross domestic product (GDP) is projected to consent 2020 sharply by up to eight, and global trade will decrease by up to 32% in 2020 thanks to the COVID-19 pandemic (World Trade Organization, 2020). Supply chain disruptions cause significant challenges and may affect organization performance (Hendricks & Singhal, 2003). Pettit et al., (2019) offer a review of the literature on supply chain resilience that predates COVID-19. The severity of the business disruption of the COVID-19 pandemic has challenged much of our previous understanding of what constitutes a resilient supply chain. Recent research has indicated that

this crisis has led to the rapid deterioration of several business and economic indicators, including productivity and global GDP (Harris, 2020). These impacts are due to the imposition of travel and trade restriction (Baveja et al., 2020) and the shutting down of workplaces. Ivanov (2020), considered the pandemic and the respective supply chain risks, provided a simulation model for global supply chain disruption, and predicted the severity of COVID-19 impact on supply chain performance.

In summary, COVID-19 has put some significant and unprecedented strain on global supply chains across most product categories. Past literature has provided some indication of the factors that may cause disruption on the supply chain. However, at the same time, it has exposed a number of challenges related to identifying and responding to significant changes within the demand patterns during an outbreak. However, the power to forecast excess demand during the pandemic early could have substantial implications for supply chain managers and policy makers.

3. METHOD

The proposed method consists of three steps to solve the interrelationships and prioritize the problem of IRR criteria.

3.1 The grey-DEMATEL methodology

The gray-DEMATEL decision matrix usually uses a gray 5-digit spectrum that includes the expressions without impact (0.25 and 0), very low impact (0.25 and 0.5), low impact (0.5 and 0.25), high impact (0.75 and 0.5), impact is very much (1 and 0.75). Therefore, the first step of the gray DEMATEL method is forming a direct communication matrix. In the next steps, the normalization operation is performed, the matrix is determined, the matrix is multiplied, and finally, the total communication matrix (T) is obtained.

As indefinite numbers, we have the operations of multiplication, division, and addition. In gray numbers, these relations are also established.

The gray-DEMATEL method is a decision-making method for performance and a way to help visualizing a complex causal relationship using useful matrices and diagrams. Matrices or diagrams depict the relationships between system components with the strengths of the relationships within these quantitative relationships. The gray-DEMATEL consists of four main steps, including developing a direct pairwise relationship matrix between system components through the evaluator or decision-maker inputs, the determination of the initial impact matrix through the normalization of the natural relationship matrix. Determining the matrix (impact) of total relationships and finally determining causal relationships (causal-salient diagrams) are among the components and relative strengths. A summary of the steps is shown next:

Step 1: Form a group of experts to gather their group knowledge to solve the problem.

Step 2: Determine the criteria to be evaluated and design language scales. In this step, experts' opinions, research factors and indicators are the main outcomes.

The criteria to be evaluated will be selected according to the areas under study. The gray numbers used in this study are of the fuzzy triangular type. As can be seen, this spectrum is the same as the spectrum of the DEMATEL method, except that gray numbers are used.

Step 3: Create a gray matrix of direct initial communication with the collection of expert opinions.

To measure the relationships between criteria, we need to put them in a square matrix and ask experts to compare them in pairs based on how much they affect each other. In this survey, experts will express their views based on gray numbers. Assuming we have n criteria and p experts; we have a gray matrix, each of which corresponds to the opinions of an expert with gray numbers as its elements.

Step 4: Normalize the direct connection gray matrix.

For this purpose, linear scale conversion is used as a normalization formula to convert benchmark scales to similar criteria.

Step 5: Calculate the matrix of the total connection. In this step, first, calculate the inverse of the standard matrix and then subtract it from the matrix I, and finally multiply the standard matrix by the resulting matrix.

Step 6: Create and analyze the causal chart.

For this purpose, we first calculate the sum of the elements of each row (Di) and the sum of the elements of each column (Ri) of the gray matrix. The sum of the elements of each row (D) for each factor indicates the extent to which that factor influences other factors in the system. The sum of the column (R) elements for each factor indicates the degree to which that factor is affected by different factors in the system.

Then we get the values D + R and D-R. To draw a causal diagram, we must de-fuzzy these two values, like the definitive DEMATEL method. Therefore, the horizontal vector (D + R) is the influence of the system's desired factor. In other words, the higher the D + R vector, the more it interacts with other system factors. The vertical vector (D - R) indicates the power of each aspect. In general, if D - R is positive, the variable is causal, and if it is negative, it is a disability. After deactivating the numbers, a Cartesian coordinate system is drawn. The longitudinal axis shows the values D + R, and D-R is the transverse axis in this device.

Therefore, the horizontal vector in the coordinate system is the degree of impact of the desired factor in the system. In other words, the higher the value for an aspect, the more the factor interacts with other system factors.

The vertical vector of the coordinate system shows the effect of each factor.

3.2 DANP

This approach is one of the newest techniques for combining gray-DEMATEL with ANP, known as fuzzy DANP.

As mentioned, the degree of importance of each element under the control of the other component was measured using the ANP method. Because of facilitating the work and reducing the number of pairwise comparisons required, the internal connections and the degree of influence of the elements on each other are measured by the DEMATEL method. The number of even comparison matrices and the volume of calculations are reduced, the speed of calculations is increased, and its complexity is reduced. In this technique, after forming the total gray-DEMATEL communication matrix, the threshold value is no longer calculated, i.e., no relation is eliminated. From this matrix, the ANP supermatrix is formed with a series of other steps, and then it is possible to converge. The converged matrix is the limit supermatrix that represents the final weights of the factors.

In the integration of gray digital technique and network analysis process in the first phase, the external weight coefficients required to form the initial heterogeneous supermatrix are obtained from matrices pairwise comparisons of elements to the target cluster.

Yang & Tzeng (2011) expansion analysis technique can be used to determine the weighting coefficients of factors in this section. In the second phase, the internal weighting coefficients required to form the initial unbalanced supermatrix are obtained from the diffuse communication matrix of the DEMATEL technique at the level of clusters and elements. In this method, the initial heterogeneous supermatrix is formed according to the defined pattern and finally converges. This method was invented by Tezang and has been used by many people, including (Kahraman et al. 2014). Due to its positive features and capabilities, this method is used in this research.

3.3 gDANP

Step 1. We formulate the effect matrix of all the criteria. Gray-DEMATEL method is used to calculate the total effect of the matrix from each dimension or inhibitory measure with different degrees of effective relationship.

Step 2. Formulation of the weightless supermatrix. After obtaining the standard matrix, the normalization of the initial matrix with the degree of overall effect will be accepted.

Step 3. Calculation of supra-matrix weight matrix of total dimension relations matrix obtained by the gray-DEMATEL method.

Step 4: Limit the supermatrix. As with the conventional ANP method, limiting the supermatrix to power provides a stable weight of criteria. Likewise, the proposed gDANP supermatrix must reach sufficient power. Therefore, the effective weights of each criterion can be obtained.

4. EXPECTED RESULTS

In this study, the gray network analysis method will be used to determine the weight of the criteria and model indices.

Railway policymakers will be able to develop the proposed gDANP evaluation framework between models and logistics operations organizations to evaluate IR more effectively. IRR upgrades and having a strategic plan to upgrade their barriers. Managers can gain valuable managerial insights from many charts

Use the above convergent cause, effect, and criteria to identify insightful decisions.

If procurement and transportation policymakers want to reach the highest level of performance, they will be advised to pay more attention to "deterrence". This level is because factors have a significant effect on the criteria.

The findings of this study will provide a list of priority criteria before and after the spread of coronavirus. By prioritizing impact indicators in both pre- and post-virus situations, logistics policymakers will be able to revise transportation policies. Logistics policymakers can use the proposed framework to analyze the impact of IRR factors on future IRR system development. This study will also provide the next important IRR metrics that may suggest that adequate policy action be taken.

5. CONCLUSIONS

The rail-based freight system has become essential to policymakers in recent years due to its commitment to a sustainable strategy.

Therefore, road freight transportation towards rail transportation and their integration have been given priority. In a complex process of decision and evaluation, many criteria include subjective and qualitative judgments. In such circumstances, MCDM methods can be an effective solution for calculating the barriers to cross-communication of priority importance.

The proposed framework analysis was considered by using an integrated MCDM method, for example, DEMATEL-ANP gray (gDANP), to validate the proposed framework. Experts from different departments of freight organizations are considered.

It is hoped that the results of the post-searcher computational results will confirm that the proposed model will help transport policymakers and stakeholders to improve them.

The decision-making process improves the share of intermodal services, especially in cases where many criteria are interrelated.

The results of future calculations will be presented in the form of ranking and correlation of all criteria.

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