# Analysis of relationships of third party logistics enablers using multi-criteria decision making technique DEMATEL-based on ANP 

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#### Abstract

Globalisation and adapting to market conditions, the existence of competitive pressures, such as the entry of emerging companies into the competition market and the need for increased investment costs, has led manufacturers to improve their innovative ways of serving customers. The third party logistics (3PL) Provider is an external supplier that manages, controls and performs logistic activities on behalf of the customer. In this paper, seven major dimensions of third-party logistics enablers have been evaluated with MAXQDA(v11) software and using literature review, text content analysis and specialised interview with 16 experts from the logistics industry, then using the DANP technique. The results of the Analysis in relation-impact diagrams show that the most important enablers are: manufacturing, technical and marketing and sales, financial, human resources and strategic enablers, respectively. Also, technical and manufacturing enablers are of the most influential enablers, and has the most interaction with other enablers as well.


Keywords: third party logistics; 3PL; empowerment; DEMATEL-based on ANP; DANP; multi-criteria decision making.

Reference to this paper should be made as follows: Aliei, M., Kazemi, M., Saghih, A.M.F. and Naji-Azimi, Z. (2020) 'Analysis of relationships of third party logistics enablers using multi-criteria decision making technique DEMATEL-based on ANP (DANP)', Int. J. Procurement Management, Vol. 13, No. 2, pp.225-256.

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## 1 Introduction

Today, organisations outsource some of their affairs not only to reduce costs but seek to maintain and enhance their status. As outsourcing of activities become one of the most important strategic considerations of the 21st century (Aktas and Ulengin, 2005). Globalisation and increased competition compel companies to pay more attention to their outsourcing decisions (Ahearne and Kothandaraman, 2009). In addition, outsourcing of activities can lead to learn and change. Bento et al. (2013), with a case study of the outsourcing of activities of several companies, have shown that outsourcing can lead to profound operational changes as a launch platform. Williamson (2015) states that companies should outsource activities that are performed internally but require additional investment to achieve lower unit costs (Momme, 2001). McCray and Clark (1999) believed in the late 1990s that the potential costs and benefits of outsourcing were uncertain, and deciding to outsource was heavily dependent on the situation. There is a great deal of evidence that organisations are failing to meet the goals of outsourcing. This situation has turned outsourcing into one of the most difficult and controversial issues in today's business world. Research conducted on industry executives has shown that many
outsourcing contracts fail to fulfil their primary goals (Duening and Click, 2005). However, after two decades, outsourced production had one of the fastest growths among industries in the field of electronics, pharmaceuticals, automobiles, food and beverages (Hafmann and Osterwalder, 2017). In addition, the turnover of this area is also significant. In addition to the cost advantage of outsourcing, researchers have cited other issues such as acquiring new knowledge technologies (Malakootinejad, 2016). As the supply chain performance is one of the key competitive tools, the importance of thirdparty logistics companies will be more in the future, and the role of such companies will be more and more bold and complex in the success of supply chains (Briggs et al., 2010). As third-party logistics companies are expanding the realm of their activities and taking on more roles in various supply chains. In other words, the activity scope of these companies is no longer limited to warehousing and transportation matters, and third-party logistics companies are expected to play roles such as managing suppliers and inventories, distributing final products (along with packaging, labelling, etc.), providing customer support services and even managing returned goods. In order to provide such value-added services to their customers, third-party logistics companies must upgrade their technological capabilities, improve their long-term relationship management, and have a deep understanding of the capabilities that make competitive advantage for their customers (Schittekat and Sörensen, 2009). The country's specific conditions, such as sanctions, lack of infrastructure, lack of proper insurance conditions, lack of expertise, and the specific regional situation of Iran in the way of silk, has led companies active in the field of domestic and international transport and Support is subject to fundamental constraints. Also using the existing world-class approaches, cannot prescribe a similar version to empower existing logistics companies in Iran, since the first-world companies in this field are much ahead of Iranian companies and have reached maturity. And the use of existing approaches may cause many aspects to be neglected. Due to the ability of some of the traditional domestic companies to become 3PLs, this study seeks to introduce and explore the relationship between enablers.

## 2 Third party logistics

According to Lieb and Bentz (2004), third-party logistics is performing logistic tasks of an external firm that was traditionally carried out by the firm itself. The operations performed by the third-party firm could include all or part of the process of logistic activities (Lieb and Bentz, 2004). Meanwhile, Berglund with emphasise on the provision of management services, in addition to carrying out operational activities by third party logistics (3PL) providers during the period of customer-3PL relationship believes thirdparty logistics are activities that are performed by logistics services providers, and at least include managing and implementing transportation and warehousing. In addition, these activities can include inventory control and management, information activities such as product tracking, value added activities such as assembly and installation of products - or even supply chain management activities. Also, this contract should include some management, analysis, or design activities. To distinguish traditional transportation from third-party logistics, the length of cooperation between the customer and the supplier should be one year or more (Berglund et al., 1999). Murphy and Poist (2008) emphasises on the length of cooperation and the nature of the relationship in the 3PL. In their
opinion, third-party logistics establishes a relationship between the customer and the provider of those services that is customised and localised compared to the traditional services, and covers more diverse services, the main feature of this relationship is an increase in the length of cooperation period and the consent of the parties (Murphy and Poist, 2008). With this definition, third-party logistics is distinguished from traditional outsourcing of the logistics. To call a relationship based on third-party logistics, the realisation of several characteristics - like the provision of a wide range of logistics services and the fair sharing of profits and risk-is necessary. Also, in third-party logistics contracts, tactical cooperation is replaced by strategic partnerships [Mafakher, (2016), p.73]. The completed survey shows that transportation function, warehousing and customs brokerage are typical functions for outsourcing activity (Hilmola and Tan, 2009). In this article, six empowers include:

1 technical empowerment (A)
2 productive empowerment (B)
3 strategic empowerment (C)
4 financial empowerment (D)
5 marketing and sales empowerment (E)
6 staff empowerment (F).

## 3 Literature review

Studies have shown that there is little research on third-party logistics, so that research conducted on supply chain integration has not taken into account the role of third-party logistics companies and identifying the importance of 3PL provider's enablers and their interaction with each other and how companies move and accelerate in the path to provide third-party logistics services, and there is a research gap in this area. Few researches on the 3PL provider's enabler components have been reported. We will briefly mention a number of third-party logistics researches in the following:

Hafmann and Osterwalder (2017) examined the role of information technology as an enabler in 3PL business models and has shown that information technology can replace or complete many logistics activities. Durst and Evangelista (2018) have concluded that the use of sophisticated and integrated knowledge management systems is considered as essential to support the specific needs of logistics service companies as well as to enhance the collaboration with other supply chain actors. Evangelista and Durst (2015) conducted a research to rank the factors influencing the third-party logistics companies in IT industry. Flexibility, reliability, trust and information sharing, incomplete delivery, storage system, storage costs, customer satisfaction, operating speed, transport system, economic status, after sales service, satisfying customer requirements, delivery performance, IT capability, social responsibility, distribution costs, accountability and environmental responsibility is crucial to choose logistics companies. Samar and Sadia (2018) have shown that four satisfaction level from service user's perspective is measured with the help of the US customer satisfaction index: process related, information related, services related and user's expectation related. Jung (2017) investigated the third-party logistics in terms of social sustainability. Philanthropy, the
price of services, services tailored to customer demand, management policies including organisational learning plans, respect for rights of others, employee health, and average salaries are among the most important criteria in the third-party logistics assessment. Hafmann and Osterwalder (2017) in their article entitled 'Third-party logistics providers in the digital age: towards a new competitive arena' have suggested that digitisation has created many innovations in the field services, and with the support of a variety of industries, has many capabilities for product development. To this end, it is recommended that 3PL enters to the market in four steps:

1 Defining industry and business models and activities related to the supply chain and logistics.

2 Screening and analysis of how digitalisation affects production processes (replacement, complement, without effect).

3 Identifying the threats posed by digitisation.
4 Identifying the opportunities arise by digitisation.
In order to achieve a comprehensive approach, it is recommended that these steps be carried out in teams and groups, and it is cleared that activities are replaced by digital technologies (replacement) or logistics activities are not affected by digitisation (without effect) or that activities are completed by digitisation. Olfat (2016) has compiled the factors influencing logistics outsourcing and modelled it using structural equation mode: core activities (Kristensen and Zeitlin, 2001), previous experiences of the organisation, activity features, need to invest, capacity development, organisation strategy, resource liberalisation (Pratap, 2014), similar action by rivals (Gewald and Dibbern, 2009), organisation size, information sensitivity, cost-effective scale, cost (Lacity and Willcocks, 2014), competitiveness (Popa and Salantă, 2014), service quality (Shi, 2013), service flexibility, service speed (Wu and Park, 2009), management support (Marshall et al., 2015), market development (Jiang et al., 2007), New knowledge and innovation (Novak and Stern, 2008), and at the last component level, has identified a competitive advantage that has been modelled so that all of these criteria affect the competitive advantage. These factors are classified into five levels and two groups of related and dependent variables.

## 4 Research methodology

This research is an applied research in terms of purpose and is a qualitative-quantitative research in terms of methodology. The statistical population of the study is experts in the field of logistics, including managers and specialists in this field. In order to identify the experts, criteria have been considered regarding the degree of education (Table 1). In the first phase of this research we seek to identify enablers, by selecting academic papers and related documents, as well as conducting 16 interviews with industry experts, seven major enablers has been identified. In the second phase, enablers are weighted and the relationship between criteria and sub-criteria is characterised with combined DEMATEL-based on ANP (DANP) method.

Table 1 Identification criteria for experts

| Degree (industrial engineering, industrial <br> management, manufacturing or logistics-related) | Lowest experience in logistics (years) |
| :--- | :---: |
| Bachelor | 8 |
| Master | 4 |
| PhD | 1 |

According to the Logistics Association of Iran, almost all third-party logistics companies have a central or representative office in Tehran, for this reason, a sample of 3PL companies that have a central or representative office in Tehran are selected, which are sampled based on is a non-probability sampling technique or Judgmental sampling technique. The sample consists of 14 different companies operating in different industries: the road transport industry (two companies), aviation transport industry (three companies), marine transport industry (three companies), distribution and distribution (four companies) and warehousing (two companies).

### 4.1 Validity and reliability evaluation based on Cohen's Kappa coefficient method

In the next step of the study, in order to evaluate the reliability of the research, Cohen's Kappa coefficient was used to determine research core codes and enablers. The inter-rater reliability was used to evaluate reliability. In addition to the researcher who attempted code the articles and interviews initially, a second researcher code again the coded texts without knowing its codes, If the codes of these two coders are closely aligned, indicates a high agreement between the two rater that expresses the reliability (Cohen, 1960). Table 2 shows the Cohen's Kappa coefficient texts coded by scholar and expert. The Cohen's Kappa coefficient is estimated at 0.739 with SPSS software, which shows that the expert group has a very strong agreement on coding.
Table 2 Cohen's Kappa coefficient

|  | Value | Asymptotic <br> standard error $^{a}$ | Approximate <br> $T^{b}$ | Approximate <br> significance |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Measure of agreement | Kappa | .730 | .101 | 11.806 | .000 |
| N of valid cases |  | 20 |  |  |  |

Notes: ${ }^{a}$ Not assuming the null hypothesis. ${ }^{\text {b }}$ Using the asymptotic standard error assuming the null hypothesis.

In the second step, weighting and analysing the relationships of enablers is addressed, the validity of the questionnaires was confirmed by a formal concept analysis. Also, the reliability of paired comparison questionnaires was investigated by calculating the inconsistency rate. Since the inconsistency rate was 0.039 , the reliability of the questionnaire was approved at the desired level.

### 4.2 Third party logistics enablers

By reviewing the literatures and conducting interviews with logistics experts, 245 codes have been extracted. among them 12 codes from related books, 36 codes from Latin
theses, 76 codes from Latin articles, 78 codes from Persian articles and 43 codes from specific interviews with experts have been obtained with MAXQDA (v12) software. These codes are categorised in 17 core codes and finally classified in six categories or dimensions of the 3PL empowerment. These six main dimensions include (Table 3): technical enablers, production enablers, human resource enablers, strategic enablers, marketing enablers, project management enablers and financial enablers.

Table 3 Third party logistics enablers

| Main criteria | Sub-criteria | Reference |
| :---: | :---: | :---: |
| A: Technical empowerment | Logistics equipment | Jung (2017), Sahay and Mohan (2006) and Joo et al. (2013) |
|  | Expertise in specific industry and experience | Gholami and Akbari Jokar (2014), Jung (2017), Kasai et al. (2012) and Aguezzoul (2007) |
|  | Secure electronic data exchange | Gholami and Akbari Jokar (2014) and Olfat (2016) |
| B: Productive empowerment | Communication with other logistics providers | Razik and Sheng (1998), Hafmann and Osterwalder (2017), Malakootinejad (2016) and Fassoula (2006) |
|  | Speed and quality control and considering standards | Gholami and Akbari Jokar (1994), Halldorsson and Skjøtt (2004) and Joo et al. (2013) |
|  | Flexibility and innovation | Naim et al. (2010), Gholami and Akbari Jokar (1994), Le Fevre and Robinson (2015), Hertz and Alfredsson (2003) and Giannikas et al. (2019) |
| C: Strategic empowerment | Senior management support | Olfat (2016), Tezuka (2011) and Anderson et al. (2011) |
|  | Systemic and futuristic look | Gholami and Akbari Jokar (1994), Aguezzoul (2007) and Aas et al. (2008) |
|  | Introduction to legal and tax laws | Hopwood (2009), Arnold and Clark (1998) and Koberg and Longoni (2019) |
| D: Financial empowerment | Financial stability | Bagherinejad (2001), Jung (2017) and Joo et al. (2013) |
|  | Attract investor | Jung (2017) and Joo et al. (2013) |
|  | Reduced operational costs | Rajesh et al. (2013), Kumar et al. (2006) and Aguezzoul (2007) |
| E: Marketing and sales empowerment | Maintaining long-term customer relationships | Gholami and Akbari Jokar (1994), Samar and Dubey (2014) and Tezuka (2011) |
|  | Geographic coverage and new markets | Mitra and Webster (2008), Gholami and Akbari Jokar (1994), Malakootinejad (2016) and Vaggelis et al. (2019) |
|  | Skills in fair negotiations | Bhatnagar et al. (1999), Aguezzoul (2007), Wang (2009) and Bagherinejad (2001) |
| F: Staff empowerment | Organisational learning and training of parties | Le Fevre and Robinson (2015), Jung (2017), Missimer et al. (2017) and Liu and Wang (2009) |
|  | Safety and health of employees | Harik et al. (2015), Wolf, C. and Seuring (2010) and Anderson et al. (2011) |

### 4.3 Weighing and analysing enablers relationships with DANP technique

In DANP method, the results are obtained based on analytical network process (ANP) basis from the total relation matrix TC (for sub criteria) and TD (for criteria) calculated by DEMATEL. Therefore, the DEMATEL method is used to construct a network structure model for each and every dimension and also to improve the traditional ANP normalisation process (Chu et al., 2008). This technique is very suitable for real-world issues in comparison with traditional methods and considers the relationship between criteria. Finally, DEMATEL combines with ANP to form DANP in order to determine the effective weights of each dimension and criteria (Lu et al., 2013). Examples of papers used in the DANP method include: developing a green supplier selection model (Kuo et al., 2015), the selection of an outsourcing provider (Hsu et al., 2013), The best vendor selection for conducting the recycled material (2012), improving e-store business (Chiu et al., 2013

Yang et al., 2017) and establishing the model of e-learning service quality (Yang et al., 2017). The steps to establish the structure of the network relations using the DEMETAL technique and determining the effective DANP weights based on the total relation matrix are described below. Thus, the steps of DANP technique are (Hsu et al., 2012).

## Step 1: generating matrix of survey respondents

In the first step, each respondent is asked to determine a direct effect that the element $i$ has on element $j$. It is necessary to note that in the DANP all the sub-criteria will be pair-compared with each other and the effects of the criteria will be calculated after the identification of the sub-criteria effects. This effect can be represented by a score of integers between zero and four. Accordingly, the zero number indicates that the element $i$ does not affect the element $j$, the number 1 indicates that it has a small effect, number 2 indicates that it has a moderate effect, number 3 indicates that it has a large effect, and the number 4 indicates that the element $i$ has a great influence on $j$. Thus, for each respondent, the matrix $P$ is:

$$
P^{p}=\left[P_{i j}\right]_{n \times n}=\left[\begin{array}{ccccc}
p_{11} & \cdots & p_{1 j} & \cdots & p_{1 n}  \tag{1}\\
\vdots & & \vdots & & \vdots \\
p_{i 1} & \cdots & p_{i j} & \cdots & p_{i n} \\
\vdots & & \vdots & & \vdots \\
p_{n 1} & \cdots & p_{n j} & \cdots & p_{n n}
\end{array}\right]
$$

## Step 2: creating the initial decision matrix

This matrix is derived from the simple arithmetic mean of the opinions of $\rho$ expert in the preceding step. We call this matrix $A$.

$$
\begin{equation*}
A=\left[a_{i j}\right]_{n \times n} \tag{2}
\end{equation*}
$$

where

$$
\begin{align*}
& a_{i j}=\frac{1}{\rho} \sum_{\rho=1}^{n} p_{i j}  \tag{3}\\
& A=\left[\begin{array}{ccccc}
a_{11} & \cdots & a_{1 j} & \cdots & a_{1 n} \\
\vdots & & \vdots & & \vdots \\
a_{i 1} & \cdots & a_{i j} & \cdots & a_{i n} \\
\vdots & & \vdots & & \vdots \\
a_{n 1} & \cdots & a_{n j} & \cdots & a_{n n}
\end{array}\right] \tag{4}
\end{align*}
$$

By calculating arithmetic mean of opinions of 16 experts for each paired comparison, the initial decision matrix (Table 4) is obtained, which is calculated in the following form in the Excel.

Each number in the table represents the arithmetic mean of 16 experts, which is taken from a paired comparison.

In order to normalise the matrix in the next step, it is necessary to obtain the sum of the rows and columns and the maximum of these values. Also, the inconsistency rate in this method is:

$$
\begin{equation*}
I R=\frac{1}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{n} \frac{\left|g_{c}^{i j \rho}-g_{c}^{i j(\rho-1)}\right|}{g_{c}^{i j \rho}} \times 100 \% \tag{5}
\end{equation*}
$$

In this equation, $n$ is the number of sub-criteria and $g_{c}^{i j \rho}$ represents the mean of all individuals and $g_{c}^{i j(\rho-1)}$ is the average score with the elimination expert $i$. Reliability is obtained from the following equation:

$$
\begin{equation*}
\text { Reliability }=1-g \tag{6}
\end{equation*}
$$

If the value of $g$ is less than $5 \%$ (reliability greater than $95 \%$ ), the reliability of data (credit) is verified.

## Step 3: calculating the normalised direct-influence matrix

The normalised direct-influence matrix (D) is obtained by normalising the initial decision matrix A:

$$
\begin{equation*}
D=\left[d_{i j}\right]_{n \times n} \tag{7}
\end{equation*}
$$

In this matrix (Table 5), all elements on the main diagonal are equal to zero. Matrix D shows the initial effects of susceptibility and effectiveness. The matrix D is obtained using the following equation:

$$
\begin{align*}
& D=S . A  \tag{8}\\
& {\left[d_{i j}\right]_{n \times n}=S\left[a_{i j}\right]_{n \times n} \quad i, j \in\{1,2, \ldots, n\}}  \tag{9}\\
& S=\operatorname{Min}\left\{\frac{1}{\max _{1 \leq i \leq n} \sum_{j=1}^{n} a_{i j}}, \frac{1}{\max _{1 \leq j \leq n} \sum_{j=1}^{n} a_{i j}}\right\} \tag{10}
\end{align*}
$$

Table 4 Initial decision matrix


Table 5 Normalised direct-influence matrix

| D | al | a 2 | a 3 | b1 | b2 | b3 | cl | c2 | c3 | d1 | d2 | d3 | el | e2 | e3 | f1 | $f 2$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| al | 0 | 0.07247 | 0.047566 | 0.029616 | 0.076733 | 0.072919 | 0.072695 | 0.054297 | 0.076733 | 0.025802 | 0.056765 | 0.061925 | 0.072695 | 0.072695 | . 051829 | . 07247 | 353 |
| a2 | 0.032533 | 0 | 0.070002 | 0.070002 | 0.06731 | 0.067534 | 0.027148 | 0.025353 | 0.084362 | 0.056989 | 0.054521 | 0.070227 | 0.072919 | 0.079426 | 0.047566 | 0.070227 | 246 |
| a3 | 0.071797 | 0.070002 | 0 | 0.052502 | 0.057662 | 0.069778 | 0.029616 | 0.034552 | 0.070002 | 0.048239 | 0.051829 | 0.08683 | 0.054521 | 0.080323 | 0.054072 | 0.072022 | 0.047566 |
| b1 | 0.074714 | 0.03904 | 0.060803 | 0 | 0.070227 | 0.070002 | 0.076733 | 0.04779 | 0.076509 | 0.072695 | 0.051829 | 0.047341 | 0.072695 | 0.056765 | 0.04779 | 0.036347 | 0.034104 |
| b2 | 0.051604 | 0.07247 | 0.055194 | 0.05497 | 0 | 0.06820 | 0.069329 | 0.070002 | 0.072695 | 0.076733 | 0.044649 | 0.076284 | 0.061925 | 0.048014 | 0.050931 | 0.070675 | . 056316 |
| b3 | 0.070002 | 0.056989 | 0.073143 | 0.057886 | 0.070002 | 0 | 0.07067 | 0.063944 | 0.072695 | 0.054072 | 0.048463 | 0.056092 | 0.06731 | 0.059457 | 070 | . 054072 | . 047 |
| c1 | 0.034552 | 0.024905 | 0.020417 | 0.060803 | 0.079426 | 0.07247 | 0 | 0.07045 | 0.029616 | 0.044425 | 0.045995 | 0.049136 | 0.078977 | 0.048239 | 0.05497 | 0.029616 | 0.047566 |
| c2 | 0.025398 | 0.029616 | 0.008077 | 0.050482 | 0.079426 | 0.072022 | 0.071124 | 0 | 0.028046 | 0.044873 | 0.045546 | 0.039264 | 0.033655 | 0.028046 | 0.048014 | 0.03186 | 0.034552 |
| c3 | 0.069554 | 0.081221 | 0.079426 | 0.070002 | 0.070002 | 0.069554 | 0.026924 | 0.026026 | 0 | 0.072022 | 0.029616 | 0.048463 | 0.070002 | 0.070002 | 0.051829 | 0.06731 | 0.029616 |
| d1 | 0.078977 | 0.085708 | 0.070002 | 0.048912 | 0.03186 | 0.046219 | 0.046893 | 0.048014 | 0.047117 | 0 | 0.056092 | 0.080996 | 0.054521 | 0.040835 | 0.029168 | 0.056092 | 0.054521 |
| d2 | 0.040386 | 0.059457 | 0.04801 | 0.04801 | 0.04779 | 0.045546 | 0.029616 | 0.048912 | 0.023334 | 0.081894 | 0 | 0.0489 | 0.065739 | 0.033655 | 0.033655 | 0.06731 | 0.03702 |
| d3 | 0.064169 | 0.06372 | 0.043303 | 0.032533 | 0.045546 | 0.032084 | 0.033655 | 0.020193 | 0.029168 | 0.070675 | 0.052502 | 0 | 0.0246 | 0.033655 | 0.045322 | 0.061925 | 0.032084 |
| e1 | 0.032084 | 0.05654 | 0.044649 | 0.026251 | 0.04779 | 0.045771 | 0.051829 | 0.030065 | 0.047566 | 0.034104 | 0.04779 | 0.065291 | 0 | 0.048239 | 0.044873 | 0.056989 | 0.041508 |
| e2 | 0.070002 | 0.076733 | 0.070002 | 0.070227 | 0.045322 | 0.079426 | 0.029616 | 0.009693 | 0.051829 | 0.048239 | 0.034104 | 0.036347 | 0.04779 | 0 | 0.070002 | 0.047341 | 0.04779 |
| e3 | 0.056989 | 0.056989 | 0.067983 | 0.075163 | 0.052502 | 0.045546 | 0.023558 | 0.032533 | 0.028046 | 0.039713 | 0.034552 | 0.062149 | 0.070675 | 0.0709 | 0 | 0.047341 | 0.030065 |
| fl | 0.04779 | 0.070002 | 0.044649 | 0.047341 | 0.051829 | 0.056765 | 0.047117 | 0.034777 | 0.077406 | 0.034777 | 0.054521 | 0.04779 | 0.059681 | 0.042181 | 0.070675 | 0 | 0.072695 |
| f2 | 0.070002 | 0.052502 | 0.02064 | 0.07449 | 0.037245 | 0.044873 | 0.036572 | 0.05295 | 0.040835 | 0.044649 | 0.048239 | 0.045546 | 0.04779 | 0.032084 | 0.059457 | 0.041956 | 0 |

By specifying the maximum sum of the rows and columns (45.28), it is enough to normalise the matrix, all the numbers of the initial decision matrix are divided into this number. The resulting matrix will be as follows:

Step 4: the total influences matrix TD
If the power of the initial spur of matrix (D) increases (for example, $D^{2}, D^{3}, D^{4}, \ldots, D^{\infty}$ ), the direct spur of matrix decreases, which ensures that the convergent solutions to the inverse matrix are guaranteed. We can create an infinite set of direct and indirect effects. The total spur of matrix called $T$ (Table 8 ) is derived from the following equation:

$$
\begin{equation*}
T=D+D^{2}+D^{3}+\cdots+D^{m}=D(I-D)^{-1}, m \rightarrow \infty \tag{11}
\end{equation*}
$$

In this equation, ' I ' is an identity matrix in which main diagonal elements are equal to 1 and other elements are equal to zero. The resulting matrix can be counted as a breakdown of criteria that are represented by $T_{C}$ :

To do this, we need to calculate and reverse the matrix I-D. The matrix I-D (Table 6) means to subtract all elements of the main diagonal from 1, and since the elements of main diagonal are zero, then the main diagonal become 1 . And since other elements of the matrix are equal to zero, in the matrix I-D, all the elements except for the main diagonal will be negative, and the matrix I-D will be as follows.

By reversing the matrix I-D the following matrix will be resulted, then $(I-D)^{-1}$ (Table 7).

Multiplying two matrices D and $(I-D)^{-1}$, we can obtain the total direct and indirect spur of matrix $\left(T_{C}\right)$ (Table 8): which is as follows.

Table 6 Matrix I-D

|  | al | a 2 | a3 | b1 | b2 | b3 | cI | c2 | c3 | d 1 | d2 | d3 | el | $e 2$ | e3 | f1 | $f 2$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| al | 1 | -0.07247 | -0.04757 | -0.02962 | -0.07673 | -0.07292 | -0.07269 | $-0.0543$ | -0.07673 | -0.0258 | -0.05676 | -0.06193 | -0.07269 | -0.07269 | -0.05183 | -0.07247 | 535 |
| a2 | -0.03253 | 1 | $-0.07$ | 0. 07 | -0.06731 | -0.06753 | -0.02715 | -0.02535 | -0.08436 | -0.05699 | -0.05452 | -0.07023 | -0.07292 | -0.07943 | . 4757 | -0.07023 | 225 |
| a3 | -0.0718 | -0.07 | 1 | -0.0525 | -0.05766 | -0.06978 | -0.02962 | -0.03455 | -0.07 | -0.04824 | -0.05183 | -0.08683 | $-0.05452$ | -0.08032 | -0.05407 | -0.07202 | -0.04757 |
| b1 | -0.07471 | -0.03904 | -0.0608 | 1 | -0.07023 | -0.07 | -0.07673 | -0.04779 | $-0.07651$ | -0.07269 | -0.05183 | -0.04734 | -0.07269 | -0.05676 | -0.04779 | -0.03635 | -0.0341 |
| b2 | -0.0516 | -0.07247 | -0.05519 | -0.05497 | 1 | $-0.06821$ | -0.06933 | $-0.07$ | -0.07269 | -0.07673 | -0.04465 | -0.07628 | -0.06193 | -0.04801 | -0.05093 | -0.07068 | -0.05632 |
| b3 | $-0.07$ | -0.05699 | -0.07314 | -0.05789 | -0.07 | 1 | -0.07068 | -0.06394 | -0.07269 | -0.05407 | -0.04846 | $-0.05609$ | $-0.06731$ | -0.05946 | $-0.0709$ | $-0.05407$ | $-0.04779$ |
| c1 | -0.03455 | -0.0249 | -0.02042 | -0.0608 | -0.07943 | -0.07247 | 1 | -0.07045 | -0.02962 | -0.04442 | -0.046 | -0.04914 | -0.07898 | -0.04824 | $-0.05497$ | -0.02962 | $-0.04757$ |
| c2 | -0.0254 | -0.02962 | $-0.00808$ | -0.05048 | -0.07943 | -0.07202 | -0.07112 | 1 | -0.02805 | $-0.04487$ | $-0.04555$ | -0.03926 | $-0.03365$ | -0.02805 | -0.04801 | -0.03186 | -0.03455 |
| c3 | -0.06955 | -0.08122 | -0.07943 | $-0.07$ | -0.07 | -0.06955 | -0.02692 | -0.02603 | 1 | -0.07202 | -0.02962 | -0.04846 | -0.07 | -0.07 | $-0.05183$ | -0.06731 | -0.02962 |
| d1 | -0.07898 | -0.08571 | $-0.07$ | -0.04891 | -0.03186 | -0.04622 | -0.04689 | -0.04801 | $-0.04712$ | 1 | -0.05609 | -0.081 | -0.05452 | -0.04083 | -0.02917 | -0.05609 | -0.05452 |
| d2 | -0.04039 | -0.05946 | $-0.04801$ | -0.04801 | -0.04779 | -0.04555 | -0.02962 | -0.04891 | -0.02333 | -0.08189 | 1 | -0.04891 | $-0.06574$ | -0.03365 | -0.03365 | -0.06731 | $-0.03702$ |
| d3 | $-0.06417$ | -0.06372 | -0.0433 | -0.03253 | -0.04555 | -0.03208 | -0.03365 | -0.02019 | -0.02917 | -0.07068 | -0.0525 | 1 | $-0.02468$ | -0.03365 | -0.04532 | -0.06193 | $-0.03208$ |
| e1 | -0.03208 | -0.05654 | $-0.04465$ | -0.02625 | -0.04779 | -0.04577 | -0.05183 | -0.03007 | -0.04757 | -0.0341 | -0.04779 | -0.06529 | 1 | -0.04824 | $-0.04487$ | -0.05699 | $-0.04151$ |
| e2 | $-0.07$ | -0.07673 | $-0.07$ | -0.07023 | -0.04532 | -0.07943 | -0.02962 | -0.00969 | $-0.05183$ | -0.04824 | -0.0341 | $-0.03635$ | $-0.04779$ | 1 | -0.07 | -0.04734 | $-0.04779$ |
| e3 | -0.05699 | -0.05699 | $-0.06798$ | -0.07516 | -0.0525 | -0.04555 | -0.02356 | -0.03253 | -0.02805 | -0.03971 | $-0.03455$ | -0.06215 | -0.07068 | -0.0709 | 1 | -0.04734 | $-0.03007$ |
| f1 | -0.04779 | -0.07 | -0.04465 | -0.04734 | -0.05183 | -0.05676 | -0.04712 | $-0.03478$ | -0.07741 | -0.03478 | -0.05452 | -0.04779 | $-0.05968$ | -0.04218 | $-0.07068$ | 1 | -0.07269 |
| f2 | $\bigcirc 0.07$ | -0.0525 | -0.02064 | -0.07449 | -0.03724 | -0.04487 | -0.03657 | -0.05295 | -0.04083 | -0.04465 | -0.04824 | -0.04555 | -0.04779 | -0.03208 | $-0.05946$ | -0.04196 | 1 |

Table 7 Reverse matrix I-D

|  |  |  |  |  | b2 | b3 |  |  |  |  | d2 | d3 |  |  |  |  | f2 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| a | 4366 | 0.444995 | . 37292 | 0.363568 | 0.431156 | . 43762 | 35 | 310 | . 410 | 0.355815 | 0.348657 | 0.417158 | 438 | 0.40028 | 0.373406 | 0.414666 | 48 |
| a2 | 39023 | 1.390404 | 0. | 0.410338 | 0.430245 | 0.442129 | 0.324038 | 0.290963 | 0.428539 | 0.394824 | 0.355649 | 0.435833 | 0.448015 | 0.415833 | 0.378652 | 0.423177 | 0.356394 |
| a3 | 418432 | 0.449552 | 1.333258 | 0. | 0.41675 |  | 0.321828 | 0.294675 |  | 0.380323 | 0.348561 | 0.44443 | 0.425293 | 0.411673 |  |  |  |
| b1 | 0.414463 | 0.413913 | 0.38371 | 1.33 | 0.423752 | 0.4 | 0.36 | 0.30 | 0.4 | 0.39672 | 0.343574 | 0.404018 | 0.43 | 0.384747 | 0.367079 | 0.380502 | 0.311127 |
| b2 | 0.41235 | 0.46408 | 0.39 | 0.40 | 1.37 | 0.45 | 0.37035 | 0.33 | 0.42 | 0.4 | 0.354024 | 0.4492 | 0.446469 | 0.394025 | 0.388074 | 0.429898 | 0.348212 |
| b3 | 42808 | 0.449544 | 0. | 0. | 0. | 1.38768 | 0.371067 | 0.333378 | 0.423382 | 0.397155 | 0.356219 | 0.430715 | 0.451477 | 6 | 0.405652 | 0.41466 | 0.338796 |
| c1 | 0.32107 | 0.33775 | 0.29213 | 0.33 | 0.37 | 0.3 | 1.24 | 0.28 | 0.310048 | 0.3 | 0.2 | 0.346 | 0.3 | 0.320574 | 0.321565 | 0.316383 | 0.278136 |
| c2 | 0.273545 | 0.298854 | 0.244 | 0.289313 | 0.333 | 0.33298 | 0.278 | 1. | 0.27 | 0.2 | 0.256478 | 0.296429 | 0.299871 | 0.264876 | 0.278508 | 0.278991 | 0.235238 |
| c3 | 0.415168 | 0.458227 | 0.40 | 211 | 0.426469 | 0.437487 | 0.319331 | 0.28654 | 1.34560 | 0.399527 | 0.327612 | 0.410526 | 0.438807 | 0.40266 | 0.375343 | 0.414001 | 0.3125 |
| d1 | 39430 | 0.43025 | 0.36867 | 0.35578 | 0.36431 | 0.38616 | 0.3135 | 0.28 | . 360 | 1.30608 | 0.32888 | 0.40989 | 0.394303 | 0.347847 | 0.328337 | 0.3759 | 0.31 |
| d2 | 0.318229 | 0.36194 | 0.31026 | 0.31 | 0.33 | 0.3 | 0.26 | 0.2570 | 298 | 0.343224 | 1.2404 | 0.33872 | 0.360222 | 0.30 | 0.2933 | 0.343847 | 0.263745 |
| d3 | 0.317632 | 0.342057 | 0.28562 | 0.279736 | 0.30908 | 0.304817 | 0.24758 | 0.2135 | 0.281637 | 0.311407 | 0.270618 | 1.26851 | 0.299914 | 0.279821 | 0.282805 | 0.317249 | 0.240443 |
| e1 | 0.296978 | 0.34409 | 0.29446 | 0.28354 | 0.32091 | 0.32680 | 0.271021 | 0.228706 | 0.30558 | 0.287452 | 0.273111 | 0.338027 | 1.284086 | 0.301081 | 0.291957 | 0.320869 | 0.256019 |
| e2 | 0.38231 | 0.41627 | 0.36678 | 0.37095 | 0.369 | 0.4100 | 0.2928 | 0.2470 | 0.3610 | 0.34574 | 0.3024 | 0.363796 | 0.383846 | 1.305352 | 0.360534 | 0.361623 | 0.300603 |
| e3 | 0.34956 | 0.37630 | 0.34418 | 0.35441 | 0.35505 | 0.3582 | 0.27125 | 0.2516 | 0.31855 | 0.31942 | 0.286062 | 0.365855 | 0.381021 | 0.350662 | 1.275775 | 0.341175 | 0.268129 |
| f1 | 0.361919 | 0.410808 | 0.342741 | 0.352442 | 0.37713 | 0.390465 | 0.309025 | 0.271257 | 0.38224 | 0.33597 | 0.321748 | 0.374269 | 0.395399 | 0.344932 | 0.362237 | 1.317158 | 0.324243 |
| f2 | 0.341656 | 0.350266 | 0.282015 | 0.33662 | 0.323435 | 0.337503 | 0.26892 | 0.25881 | 0.310035 | 0.306316 | 0.282728 | 0.330229 | 0.341728 | 0.296404 | 0.313943 | 0.316421 | 1.222674 |

Table 8 The total influence matrix $T_{c}$

| TC | al | a 2 | a | b1 | b2 | b3 | cl | c2 | c3 | d1 | d2 | d3 | eI | $e 2$ | e3 | f1 | f2 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| al | 0.347845 | 0.485993 | 0.387597 | 0.368007 | 0.452136 | 0.449463 | 0.360064 | 0.313061 | 0.424344 | 0.360182 | 0.352164 | 0.431925 | 0.442212 | 0.404489 | 0.377427 | 0.447585 | 310874 |
| a2 | 0.39358 | 0.41225 | 0.436974 | 0.412453 | 0.45092 | 0.45332 | 0.3 | 0.292509 | 0.44 | 0.398115 | 0.358058 | 0.469088 | 0.449973 | 0.418688 | 381239 | 435119 | 648 |
| a3 | 0.423203 | 0.492945 | 0.350617 | 0.39378 | 0.440246 | 0.452321 | 0.3253 | 0.29785 | 0.44 | 0.386279 | 0.3527 | 0.4603 | 0.431267 | 0.417537 | 0.383997 | 0.43454 | 0.333925 |
| b1 | 0.419688 | 0.437728 | 0.398794 | 0.338435 | 0.467232 | 0.467419 | 0.36683 | 0.310726 | 0.423811 | 0.402581 | 0.348 | 0.419705 | 0.442835 | 0.390283 | 0.372619 | 0.395858 | 37 |
| b2 | 0.399833 | 0.467337 | 0.394118 | 0.391578 | 0.382619 | 0.446119 | 0.359255 | 0.329281 | 0.420613 | 0.406956 | 0.343334 | 0.446293 | 0.433023 | 0.38251 | 0.376496 | 0.426261 | 492 |
| b3 | 0.424015 | 0.463776 | 0.417989 | 0.40215 | 0.476252 | 0.393172 | 0.367723 | 0.330606 | 0.429563 | 0.3945 | 0.3529 | 0.437397 | 0.447365 | 0.401784 | 0.401999 | 0.420801 | 0.336586 |
| cl | 0.310689 | 0.33956 | 0.290048 | 0.32545 | 0.376 | 0.370376 | 0.236533 | 0.276767 | 0.306823 | 0.308681 | 0.281358 | 0.342695 | 0.369896 | 0.310799 | 0.311683 | 0.313162 | 269973 |
| c2 | 0.264544 | 0.299981 | 0.242486 | 0.280362 | 0.336135 | 0.328761 | 0.270132 | 0.184233 | 0.267347 | 0.273474 | 0.248475 | 0.293563 | 0.290129 | 0.256508 | 0.269874 | 0.275961 | 0.22817 |
| c3 | 0.404071 | 0.46349 | 0.40679 | 0.391604 | 0.432465 | 0.4340 | 0.31019 | 0.27845 | 0.345129 | 0.389501 | 0.31857 | 0.409557 | 0.427054 | 0.3924 | . 36533 | 0.412139 | 0.304491 |
| d1 | 0.383822 | 0.434996 | 0.368466 | 0.346201 | 0.369442 | 0.38285 | 0.3 | 0.27840 | 0.359 | 0.297626 | 0.32006 | 0.408612 | 0.383497 | 0.3386 | 3192 | . 374 | 0.304126 |
| d2 | 0.308742 | 0.364677 | 0.309237 | 0.305853 | 0.338116 | 0.337229 | 0.256316 | 0.24952 | 0.296333 | 0.334053 | 0.232826 | 0.336797 | 0.349806 | 0.29149 | 0.28466 | 0.34103 | 0.256434 |
| d3 | 0.308818 | 0.345271 | 0.285134 | 0.271757 | 0.312343 | 0.301707 | 0.240272 | 0.207162 | 0.280115 | 0.303291 | 0.263127 | 0.267885 | 0.291062 | 0.272068 | 0.274904 | 0.315441 | 0.234003 |
| e1 | 0.28766 | 0.34613 | 0.29311 | 0.27471 | 0.323657 | 0.32258 | 0.26271 | 0.2215 | 0.30310 | 0.27891 | 0.264893 | 0.335578 | 0.274634 | 0.292251 | 0.283141 | 0.317769 | 0.248685 |
| e2 | 0.37255 | 0.4215 | 0.36682 | 0.361706 | 0.3763 | 0.4073 | 0.2848 | 0.2401 | 0.3602 | 0.3372 | 0.294525 | 0.363491 | 0.373794 | 0.297311 | 0.351538 | 0.360667 | 0.293443 |
| e3 | 0.340158 | 0.380842 | 0.343572 | 0.345302 | 0.360228 | 0.355765 | 0.263491 | 0.24467 | 0.317726 | 0.311162 | 0.278247 | 0.3645 | 0.370918 | 0.341826 | 0.2679 | 0.339656 | 0.261283 |
| f1 | 0.351061 | 0.413655 | 0.341612 | 0.34205 | 0.381196 | 0.386113 | 0.299639 | 0.262989 | 0.379236 | 0.32625 | 0.312334 | 0.372171 | 0.383661 | 0.334939 | 0.351883 | 0.314974 | 0.315557 |
| f2 | 0.33226 | 0.353568 | 0.281562 | 0.327598 | 0.328079 | 0.334835 | 0.261107 | 0.25163 | 0.307877 | 0.29807 | 0.274865 | 0.32867 | 0.332023 | 0.288186 | 0.305389 | 0.314929 | 0.216397 |

## Stage 5: drawing a map of the effects and analysis for each category of sub-criteria

In this step, the sum of the rows and columns of the total relation matrix is calculated individually according to the following equation.

$$
\begin{align*}
& \boldsymbol{T}=\left[t_{i j}\right], \quad i, j \in\{1,2, \ldots, n\}  \tag{13}\\
& \boldsymbol{r}=\left[r_{i}\right]_{n \times 1}=\left[\sum_{j=1}^{n} t_{i j}\right]_{n \times 1}  \tag{14}\\
& \boldsymbol{d}=\left[d_{j}\right]_{1 \times n}=\left[\sum_{i=1}^{n} t_{i j}\right]_{1 \times n} \tag{15}
\end{align*}
$$

$r_{i}$ represents sum of the row $i$ and $d_{j}$ represents the sum of column $j$. The index $r_{i}+d_{j}$ is obtained from the sum of row $i$ and the column $j(i=j)$. This index indicates the importance of the $i$ criterion. Similarly, the $r_{i}-d_{j}$ index is the result of the difference between the sum of the $i^{\text {th }}$ row and the j column and indicates the impact or the effectiveness of criterion I (Table 9). Generally, if $r_{i}-d_{j}$ is positive ( $i=j$ ), $i$ criterion is of causal criteria. If $r_{i}-d_{j}$ is negative $(i=j)$, the $i$ criterion is an integral part of the influencer criterion group. The causal diagram is illustrated on the basis of these two indicators, which is known as the map of the relations of effect. With this map, it is possible to decide how criteria can be improved (Hsu et al., 2012). In calculating the effectiveness and influencing of the sub-criteria, it is necessary to be aware that the values of $r$ and $d$ should be used to obtain the sum of numbers at the intersection of the row and column of the sub-criteria of $D_{i j}$ in the $T_{c}$ matrix (Table 9).

In summary, Table 10 shows the relation and interaction $(r+d)$ and the impact $(r-d)$ of the variable.

Depending on the values $r+d$ and $r-d$ and the threshold determination, we can determine the relationships that are higher than the threshold in the TD table. To reduce the complexity of the ipact-relation map (IRM), Figure 1, only those elements whose levels of impact on the TD matrix are higher than thresholds are selected. The threshold is determined using the total mean of the TD matrix or is selected by managing a specified value. Eventually, the mapping of the relation-impact is drawn for the following criteria.

In the relation-impact diagrams, the vertical axis shows the value of $r_{i}-d_{i}$, that is, the amount of the impact, and if this value is positive, the variable is affected. And if $r_{i}-c_{i}$ has a negative value, the variable is effective. The horizontal axis also shows the value of $r_{i}+d_{i}$, that is, the amount of relation to other variables. The greater the value, the greater the interaction and relation of the variable with other variables.

But in order to determine the effective weights of each criterion and sub criteria we need to continue the following steps.

Table $9 \quad$ Calculating $r$ and $d$ in the full matrix of impact

| TC | al | $a 2$ | a3 | b1 | b2 | b3 | cl | c2 | c3 | d 1 | d2 | d3 | eI | $e 2$ | e3 | f1 | f2 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| al | 0.347845 | 0.485993 | 0.387597 | 0.368007 | 0.452136 | 0.449463 | 0.360064 | 0.313061 | 0.424344 | 0.360182 | 0.352164 | 0.431925 | 0.442212 | 0.404489 | 0.377427 | 0.44758 | 0.310874 | 435 |
| a2 | 0.393584 | 0.412254 | 0.436974 | 0.412453 | 0.45092 | 0.453322 | 0.325707 | 0.292509 | 0.440769 | 0.398115 | 0.358058 | 0.469088 | 0.449973 | 0.418688 | 0.381239 | 0.435119 | 0.358648 | 242812 |
| a3 | 0.423203 | 0.492945 | 0.350617 | 0.39378 | 0.440246 | 0.452321 | 0.325338 | 0.297853 | 0.444878 | 0.386279 | 0.352728 | 0.460378 | 0.431267 | 0.417537 | 0.383997 | 0.43454 | 0.333925 | 6766 |
| b1 | 0.419688 | 0.437728 | 0.398794 | 0.338435 | 0.467232 | 0.467419 | 0.36683 | 0.310726 | 0.423811 | 0.402581 | 0.348089 | 0.419705 | 0.442835 | 0.390283 | 0.372619 | 0.395858 | 0.316537 | 273086 |
| b2 | 0.399833 | 0.467337 | 0.394118 | 0.391578 | 0.382619 | 0.446119 | 0.359255 | 0.329281 | 0.420613 | 0.406956 | 0.343334 | 0.446293 | 0.433023 | 0.38251 | 0.376496 | 0.426261 | 0.338492 | . 220317 |
| b3 | 0.424015 | 0.463776 | 0.417989 | 0.40215 | 0.476252 | 0.393172 | 0.367723 | 0.330606 | 0.429563 | 0.394551 | 0.352959 | 0.437397 | 0.447365 | 0.401784 | 0.401999 | 0.420801 | 0.336586 | . 271573 |
| cl | 0.310689 | 0.339564 | 0.290048 | 0.325458 | 0.376789 | 0.370376 | 0.236533 | 0.276767 | 0.306823 | 0.308681 | 0.281358 | 0.342695 | 0.369896 | 0.310799 | 0.311683 | 0.313162 | 0.269973 | . 820123 |
| c2 | 0.264544 | 0.299981 | 0.242486 | 0.280362 | 0.336135 | 0.328761 | 0.270132 | 0.184233 | 0.267347 | 0.273474 | 0.248475 | 0.293563 | 0.290129 | 0.256508 | 0.269874 | 0.275961 | 0.22817 | 0.721713 |
| c3 | 0.404071 | 0.463496 | 0.406793 | 0.391604 | 0.432465 | 0.434091 | 0.310195 | 0.278457 | 0.345129 | 0.389501 | 0.31857 | 0.409557 | 0.427054 | 0.392416 | 0.36533 | 0.412139 | 0.304491 | . 933781 |
| d1 | 0.383822 | 0.434996 | 0.368466 | 0.346201 | 0.369442 | 0.382851 | 0.304747 | 0.278404 | 0.359171 | 0.297626 | 0.32006 | 0.408612 | 0.383497 | 0.338655 | 0.31926 | 0.37441 | 0.304126 | 1.026297 |
| d2 | 0.308742 | 0.364677 | 0.309237 | 0.305853 | 0.338116 | 0.337229 | 0.256316 | 0.24952 | 0.296333 | 0.334053 | 0.232826 | 0.336797 | 0.349806 | 0.291492 | 0.28466 | 0.34103 | 0.256434 | . 903676 |
| d3 | 0.308818 | 0.345271 | 0.285134 | 0.271757 | 0.312343 | 0.301707 | 0.240272 | 0.207162 | 0.280115 | 0.303291 | 0.263127 | 0.267885 | 0.291062 | 0.272068 | 0.274904 | 0.315441 | 0.234003 | 0.834303 |
| el | 0.287661 | 0.346135 | 0.293113 | 0.274713 | 0.323657 | 0.32258 | 0.26271 | 0.221513 | 0.303108 | 0.27891 | 0.264893 | 0.335578 | 0.274634 | 0.292251 | 0.283141 | 0.317769 | 0.248685 | 0.850025 |
| e2 | 0.37255 | 0.421574 | 0.366828 | 0.361706 | 0.376322 | 0.407312 | 0.28484 | 0.240154 | 0.360276 | 0.337276 | 0.294525 | 0.363491 | 0.373794 | 0.297311 | 0.351538 | 0.360667 | 0.293443 | 1.022643 |
| e3 | 0.340158 | 0.380842 | 0.343572 | 0.345302 | 0.36022 | 0.355765 | 0.263491 | 0.24467 | 0.317726 | 0.311162 | 0.278247 | 0.3645 | 0.370918 | 0.341826 | 0.2679 | 0.339656 | 0.261283 | . 980643 |
| $f 1$ | 0.351061 | 0.413655 | 0.341612 | 0.34205 | 0.38119 | 0.386113 | 0.299639 | 0.262989 | 0.379236 | 0.32625 | 0.312334 | 0.372171 | 0.383661 | 0.334939 | 0.351883 | 0.314974 | 0.315557 | . 630531 |
| f2 | 0.33226 | 0.353568 | 0.281562 | 0.327598 | 0.328079 | 0.334835 | 0.261107 | 0.25163 | 0.307877 | 0.29807 | 0.274865 | 0.32867 | 0.332023 | 0.288186 | 0.305389 | 0.314929 | 0.216397 | 0.531326 |
| c | 1.164632 | 1.391193 | 1.175188 | 1.132163 | 1.326104 | 1.30671 | 0.81686 | 0.739457 | 0.919299 | 0.934969 | 0.816013 | 1.013294 | 1.019346 | 0.931387 | 0.902578 | 0.629903 | 0.531954 |  |

$\begin{array}{lllllllllllllllll}\mathrm{r}+\mathrm{c} & 2.386067 & 2.634005 & 2.441954 & 2.405249 & 2.54642 & 2.578283 & 1.636983 & 1.461169 & 1.85308 & 1.961266 & 1.719688 & 1.847597 & 1.869371 & 1.95403 & 1.883221 & 1.260434 \\ 1.06328\end{array}$ $\begin{array}{llllllllllllllllll}\mathrm{r}-\mathrm{c} & 0.056803 & -0.14838 & 0.091577 & 0.140923 & -0.10579 & -0.03514 & 0.003263 & -0.01774 & 0.014481 & 0.091328 & 0.087663 & -0.17899 & -0.16932 & 0.091255 & 0.078065 & 0.000628 & -0.00063\end{array}$

Figure 1 Relation-impact diagrams of sub-criteria of enablers (see online version for colours)


Step 6: calculation and normalisation of full relation matrix of dimensions ( $T_{D}^{\alpha}$ )
The matrix $T_{D}$ is obtained from the mean $T_{C}^{i j}$, so the matrix is a square matrix with the number of rows and columns equal to the original criteria, $m$, which is obtained from the mean of numbers in the rows and columns of the $D_{i j}$ crossing point. This matrix will be normalised according to the following procedure, so that the sum of each row is calculated and each element is divided by the sum of the elements of its row. The total normalised relation matrix $T_{D}$ is represented as $T_{D}^{\alpha}$.

$$
T_{D}^{\alpha}=\left[\begin{array}{ccccc}
t_{11}^{D_{11}} / d_{1} & \cdots & t_{1 j}^{D_{1 j}} / d_{1} & \cdots & t_{1 m}^{D_{1 m}} / d_{1}  \tag{16}\\
\vdots & \vdots & \vdots & \vdots & \vdots \\
t_{i 1}^{D_{1 i}} / d_{i} & \cdots & t_{i j}^{D_{i j}} / d_{i} & \cdots & t_{i m}^{D_{i m}} / d_{i} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
t_{m 1}^{D_{m 1}} / d_{m} & \cdots & t_{m j}^{D_{m j}} / d_{m} & \cdots & t_{m m}^{D_{m m}} / d_{m}
\end{array}\right]=\left[\begin{array}{ccccc}
t_{D}^{\alpha 11} & \cdots & t_{D}^{\alpha 1 j} & \cdots & t_{D}^{\alpha 1 n} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
t_{D}^{\alpha 11} & \cdots & t_{D}^{\alpha i j} & \cdots & t_{D}^{\alpha i n} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
t_{D}^{\alpha n 1} & \cdots & t_{D}^{\alpha n j} & \cdots & t_{D}^{\alpha n m}
\end{array}\right]
$$

With the $T_{D}$, it is easy to determine the effectiveness and effectiveness of the main criteria by summing up rows and columns, and calculating the values of $r$ and $d$, and drawing and analysing relation-impact map of the main criteria. In this way we will have Table 11.

Table 10 The rate of relation and impact of enablers

| Sub-criteria | $r$ | $d$ | $r+d$ (relation: <br> horizontal axis) | $r-d$ (impact: <br> vertical axis) |
| :--- | :---: | :---: | :---: | :---: |
| a1 | 1.221435 | 1.164632 | 2.386067 | 0.056803 |
| a2 | 1.242812 | 1.391193 | 2.634005 | -0.14838 |
| a3 | 1.266766 | 1.175188 | 2.441954 | 0.091577 |
| b1 | 1.273086 | 1.132163 | 2.405249 | 0.140923 |
| b2 | 1.220317 | 1.326104 | 2.54642 | -0.10579 |
| b3 | 1.271573 | 1.30671 | 2.578283 | -0.03514 |
| c1 | 0.820123 | 0.81686 | 1.636983 | 0.003263 |
| c2 | 0.721713 | 0.739457 | 1.461169 | -0.01774 |
| c3 | 0.933781 | 0.919299 | 1.85308 | 0.014481 |
| d1 | 1.026297 | 0.934969 | 1.961266 | 0.091328 |
| d2 | 0.903676 | 0.816013 | 1.719688 | 0.087663 |
| d3 | 0.834303 | 1.013294 | 1.847597 | -0.17899 |
| e1 | 0.850025 | 1.019346 | 1.869371 | -0.16932 |
| e2 | 1.022643 | 0.931387 | 1.95403 | 0.091255 |
| e3 | 0.980643 | 0.902578 | 1.883221 | 0.078065 |
| f1 | 0.630531 | 0.629903 | 1.260434 | 0.000628 |
| f2 | 0.531326 | 0.531954 | 1.06328 | -0.00063 |

With $T_{D}$, it is easy to determine the effectiveness and effectiveness of the main criteria by adding rows and columns and calculating $r$ and $d$ values, and drawing and analysing the relation-impact map of the main criteria. By summing up the rows and columns of the matrix $T_{D}$, the amount of relation and impact can be summarised as follows Table 12.

According to the relation-impact map, Figure 2, of variables A: technical enablers with the impact of 0.18 , B: productive enablers with an impact of 0.15 and C : strategic enablers with the impact of 0.08 are of the most effective 3PL enablers. Also, the variables below the impact graph include variables F : human resource enablers, D: financial enablers, and E : marketing and sales enablers are of the most affective enablers. Also, the technical enablers (A) and productive enablers (B) due to the highest degree of relation (X-axis) in the diagram have the highest interaction and relation with other variables.

The matrix $T_{D}$ will be normalised according to the following procedure, so that the sum of each row is calculated, and each element is divided by the sum of its row elements. The total normalised relation matrix $T_{D}$ is represented as $T_{D}^{\alpha}$, Table 13.
Table 11 Full relation matrix

| $T D$ | $A$ | $B$ | $C$ | $D$ | $E$ | $F$ | $r$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| A | 0.414557 | 0.430294 | 0.35828 | 0.396546 | 0.41187 | 0.386782 | 2.398329 |
| B | 0.424809 | 0.418331 | 0.370934 | 0.394652 | 0.405435 | 0.372423 | 2.386583 |
| C | 0.335741 | 0.364005 | 0.275068 | 0.318431 | 0.332632 | 0.300649 | 1.926526 |
| D | 0.345463 | 0.3295 | 0.274671 | 0.307142 | 0.311712 | 0.304241 | 1.872728 |
| E | 0.35027 | 0.347509 | 0.27761 | 0.314287 | 0.317035 | 0.303584 | 1.910295 |
| F | 0.34562 | 0.349978 | 0.293747 | 0.318727 | 0.33268 | 0.290464 | 1.931216 |
| c | 2.21646 | 2.239617 | 1.85031 | 2.049784 | 2.111363 | 1.958142 |  |
| r+c | 4.614789 | 4.6262 | 3.776836 | 3.922512 | 4.021658 | 3.889358 |  |
| r-c | 0.18187 | 0.146966 | 0.076215 | -0.17706 | -0.20107 | -0.02693 |  |

Table 12 The amount of relation and impact

| Main criteria | $r$ | $d$ | $r+d$ (relation: <br> horizontal axis) | $r-d$ (impact: <br> vertical axis) |
| :--- | :---: | :---: | :---: | :---: |
| A | 2.398329 | 2.21646 | 4.614789 | 0.181869 |
| B | 2.386583 | 2.239617 | 4.6262 | 0.146966 |
| C | 1.926526 | 1.85031 | 3.776836 | 0.076216 |
| D | 1.872728 | 2.049784 | 3.922512 | -0.17706 |
| E | 1.910295 | 2.111363 | 4.021658 | -0.20107 |
| F | 1.931216 | 1.958142 | 3.889358 | -0.02693 |

Figure 2 Relation-impact diagrams of enablers (see online version for colours)
Main Criteria


Table 13 Full relation matrix

| $T_{D}^{\alpha}$ | $A$ | $B$ | $C$ | $D$ | $E$ | $F$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| A | 0.172852 | 0.179414 | 0.149387 | 0.165343 | 0.171732 | 0.161271 |
| B | 0.177999 | 0.175284 | 0.155425 | 0.165363 | 0.169881 | 0.156048 |
| C | 0.174273 | 0.188943 | 0.14278 | 0.165287 | 0.172659 | 0.156058 |
| D | 0.18447 | 0.175946 | 0.146669 | 0.164008 | 0.166448 | 0.162459 |
| E | 0.183359 | 0.181914 | 0.145323 | 0.164523 | 0.165961 | 0.15892 |
| F | 0.178965 | 0.181222 | 0.152104 | 0.165039 | 0.172265 | 0.150405 |

Stage 7: normalisation of the full-relation matrix metrics of criteria ( $T_{C}^{\alpha}$ )
The normalisation of $T_{C}$ with the sum of degrees of effectiveness and effectiveness of the criteria and dimensions to obtain $T_{C}^{\alpha}$ is as follows:

$$
\begin{align*}
& c_{11} \\
& \begin{array}{lllllll}
c_{12} & & & & \\
\vdots & \boldsymbol{D}_{1} & \cdots & \boldsymbol{D}_{j} & \cdots & \boldsymbol{D}_{n}
\end{array} \\
& c_{c_{1 m_{1}}} c_{11} \ldots c_{1 m_{1}} \quad \cdots \quad c_{j 1} \ldots c_{j m_{j}} \quad \cdots \quad c_{n 1} \ldots c_{n m_{n}} \\
& \left.\boldsymbol{T}_{C}^{\alpha}=\boldsymbol{D}_{i} \quad \begin{array}{cccccc} 
& \vdots \\
\vdots & c_{i 1} & c_{i 2} \\
\vdots & & c_{1} \\
\boldsymbol{D}_{n} & c_{i m_{i}} & \vdots & & \boldsymbol{T}_{c}^{\alpha 11} & \cdots \\
\vdots & \boldsymbol{T}_{c}^{\alpha 1 j} & \cdots & \boldsymbol{T}_{c}^{\alpha 1 n} \\
\boldsymbol{T}_{c}^{\alpha i 1} & \cdots & \boldsymbol{T}_{c}^{\alpha i j} & & \vdots & \boldsymbol{T}_{c}^{\alpha i n} \\
\vdots & & \vdots & & \vdots \\
\boldsymbol{T}_{c}^{\alpha n 1} & \cdots & \boldsymbol{T}_{c}^{\alpha n j} & \cdots & \boldsymbol{T}_{c}^{\alpha n n}
\end{array}\right]  \tag{17}\\
& c_{n 1} \\
& c_{n 2} \\
& c_{n m_{n}}
\end{align*}
$$

In other words, in order to normalise the $T_{C}$ matrix, the elements in the matrix must be divided into the sum of the row corresponding to the same intersection of the sub-criteria in the row and the columns corresponding to $D_{i j}$, Table 14.

## Step 8: formation of the un-weighted super matrix $W$

In this step, the transpose of the normalised full-relation matrix, $T_{C}^{\alpha}$, Table 15 , is calculated and the matrix W is obtained. For example, if a matrix $W^{11}$ such as the is empty or zero, then the matrix is independent.

Table 14 Normalised full-relation matrix

|  |  |  |  |  |  |  |  |  |  |  |  | 13 |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| al | 0.284784 | 0.397887 | 0.317329 | 0.289859 | 0.356123 | 0.354018 | 0.328086 | 0.285257 | 0.386657 | 0.3147 | 0.307762 | 0.377468 | 0.361246 | 0.33043 | 308323 | 90124 |  |
| a2 | 0.3166 | 0.33171 | 0.35160 | 0.313249 | 0.342463 |  | 0.30756 | 0.276217 | 0.416219 | 0.324923 | 0.29223 | 0.382847 | 0.360007 | 0.334977 | 0.305016 | 0.548169 | 51831 |
| a3 | 0.3 | 0.389137 | 0.276781 | 0.306123 | 0.342245 | 0.351632 | 0.304604 | 0.278871 | 0.416525 | 0.322064 | 0.294091 | 0.383845 | 0.349827 | 0.338689 | 0.311484 | 0.565465 |  |
| b1 | 0.33409 | 0.348451 | 0.317458 | 0.265838 | 0.367008 | 0.367155 | 0.333068 | 0.282127 | 0.384805 | 0.343976 | 0.297417 | 0.358607 | 0.367273 | 0.323688 | 0.309039 | 0.555672 | 0.444328 |
| b2 | 0.317004 | 0.370524 | 0.312472 | 0.32088 | 0.313541 | 0.365576 | 0.323902 | 0.296877 | 0.379221 | 0.34009 | 0.286929 | 0.372973 | 0.363265 | 0.32089 | 0.315845 | 0.557384 |  |
| b3 | 0.324722 | 0.355171 | 0.320107 | 6261 | 0.374538 | 0.309201 | 0.326027 | 0.293118 | 0.380855 |  | 0.297879 | 0.36914 | 0.357564 | 0.321132 | 0.321304 | 0.555596 | 0.444404 |
| cl | 0.3 | 0.361123 | 0.308463 | 0.303422 | 0.351278 | 345 | 0.288411 | 0.33747 | 0.374119 | 0.3309 | 0.301648 | 0.367409 | 0.372737 | 0.313186 | 0.314077 | 0.537031 | 0.462969 |
|  | 0.327807 | 0.371719 | 0.300474 | 0.29659 | 0.355602 | 0.3478 | 0.37429 | 0.255272 | 0.370435 | 33534 | 0.304686 | 0.359974 | 0.355328 | 0.314151 | . 330521 | 0.5474 |  |
| c3 | 0.31707 | 0.3 | 0.319214 | 0.311251 | 0.343728 | 0.345021 | 0.33 | 0.298204 | 0.369604 | 0.348507 | 0.285041 | 0.366452 | 0.360444 | 0.331208 | 0.308347 | 0.575107 | 0.424893 |
| d1 | 0.323277 | 0.366379 | 0.310344 | 0.31515 |  | 0.348524 |  |  | 81155 | 0.2899 | 0.311859 | . 98142 | 368247 | 0.325189 | 0.306565 | 0.551791 | 迷 |
| d2 | 0.31 | 0.37 | 0.314695 | 0.311714 | 0.344 | 436 | 0.319528 | 0.311057 | 0.369415 | . 3.369 | 0.257 | 0.372697 | 0.377777 | 0.314801 | 0.307 | 0.570797 | 42 |
| d3 | 0.328802 | 0.367614 | 0.303584 | 0.30679 | 0.352608 | 0.340601 | 0.330249 | 0.28474 | 0.385011 | 0.363526 | 0.315386 | 0.321088 | 0.347316 | 0.32465 | 0.328034 | 0.574109 | 0.425891 |
| 1 | 0.310344 | 0.3734 | 0.3 | 0.29829 | 0.351438 | 0.3502 | 0.333672 | 0.281346 | 0.384982 |  | 0.301226 | 0.381607 | 0.323089 | 0.343814 | 0.333097 | 0.560979 | 0. 439021 |
| 2 | 0.3 | 0.3 | 0.315972 | 0.315807 | 0.3 | 0.355625 | 0.321755 | 0.2 | 0.406967 | 0.338871 | 0.295918 | 0.36521 | 0.365518 | 29072 | 0.343754 | 0.551386 | 0.448614 |
| e3 | 0.319526 | 0.357742 | 0.3227 | 0.32535 | 0.33942 | 0.335218 | 0.3190 | 0.29625 | 0.384709 | 0.326196 | 692 | 0.382112 | 0.378239 | 0.348573 | 0.273188 | 0.565 | 0.434791 |
|  | 0.31 | 0.3 | 0.30878 | 0.308331 | 0.343618 | 0.348051 | 0.318134 | 0.2 | 0.402644 | 0.322778 | 0.30 | 0.368211 | 0.3584 | 0.3 | 0.328714 | 0.4 | 0.500463 |
| f2 | 0.34346 | 0.3 | 0.2 | 0.330736 | 0.331221 | 0.338043 | 0.3 | 0.306637 | 0.375179 | 0.330 | 0.304862 | 0.364539 | 0.358712 | 0.311351 | 0.32 | 0.592723 | 0.40727 |

Table 15 Un-weighted super matrix (see online version for colours)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 0.283405 | 0.349625 | 0.34804 | 0.321168 | 0.316475 | 0.32032 | 0.33157 | 0.328663 | 32219 | 0.33315 | 0.327553 | 0.333346 | 0.321106 | . 320179 | 0326096 | 0.33034 | 3548 |
| a2 | 0.359266 | 0.293629 | 0.35808 | 0.333926 | 0.3 | 0.33264 | 0.33 | 0.335381 | 0.336 | 0.339822 | 0.3 | 0.336915 | 0.339465 | 0.337256 | 0.333143 | 0.342268 | 0.35083 |
| a3 | 0.35732 | 0.356746 | 0.29387 | 0.34490 | 0.347132 | 0.347038 | 0.33245 | 0.335956 | 0.34114 | 0.327025 | 0.332573 | 0.329738 | 0.33943 | 0.342565 | 0.340761 | 0.327392 | 0.313682 |
| b1 | 0.2 | 0.29 | 0.2 | 0.253012 | 0.320689 | 0.306258 | 0.292751 | 0.2 | 0.296563 | 0.302325 | 0.303118 | 0.304143 | 0.2967 | 0.298904 | 0.299315 | 0.2 | 0.29791 |
| b2 | 0.371902 | 0.360146 | 0.36 | 0.381019 | 0.31 | 0.389368 | 3592 | 0.353 | 0.3600 | 0.3508 | 0.345 | . 351 | 0.3534 | 0.354176 | 356357 | . 360 | 0.359109 |
| b3 | 0.36430 |  | 0.3437 | 0.3659 | 0.364315 | 0.304374 | 0.3479 | 0.351378 | 0.343359 | 0.34682 | 295 | 0.344786 | 0.349791 | 34692 | 0.344328 | 0.347971 | 0.342981 |
| cl | 0.3156 | 0.31 | 0.31 | 0.33428 | 5815 | 3308 | 0.288824 | 0.391691 | 0.3401 | 0.3361 | 0.330908 | 0.329694 | 0.33169 | 0.312803 | 0.330 | 0.3212 | 0.33 |
| c2 | 0.2 | 0.25 | 0.2500 | 0.2626 | 0.260837 | 2707 | 90 | 0.222228 | 0.2 | 0.265 | 0.266008 | 0.2526 | 0.2579 | 0.254054 | 0.259308 | 0.25448 | 0.262 |
| c3 | 0.4 | 0.4 | 0.439446 | 0.40304 | . | 0.398389 | 0.392112 | 0.386081 | 0.385173 | 0.398673 | 0.402485 | 02 | 401 | 0.433144 | 0.409783 | 0.42432 | 0.40561 |
| d1 | 0.3 | 0.321573 | 0.32031 | 33193 | 0.329035 | 0.324976 | 0.332915 | 0.336935 | 0.331418 | 0.288425 | 0.357792 | 0.361069 | 0.32889 | 0.33565 | 0.326087 | 0.327881 | 0.33568 |
| d2 | 0.304696 | 0.309236 | 0.308148 | 0.31488 | 0.317459 | 0.312994 | 0.319182 | 0.312445 | 0.306781 | 0.341179 | 0.272648 | 0.327972 | 0.314725 | 0.311 | 0.311741 | 0.316217 | 0.314906 |
| d3 | 0.3 | 0.369191 | 0.3715 | 0.35319 | 0.353506 | 0.36203 | 0.347903 | 0.35062 | 0.361801 | 0.370397 | 0.36956 | 0.310959 | 0.356384 | 0.35335 | 0.362172 | 0.3559 | . |
| el | 0.347716 | 0.35 | 0.35 | 0.3 | 0.354781 | 0.3526 | 0.3627 | 0.3482 | 0.358258 | 0.3614 | 0.3559 | 0.3493 | 0.3117 | 0.366897 | 0.378117 | 0.352 | 0.3621 |
| e2 |  |  | 0.333613 | 0.33061 | 8068 | 261 | 20 | 0.3 | 3303 | 0.323 | 0.321 | 325 | 0.3453 | 0.289141 | 0.345099 | 0.317691 | 0.316 |
| e3 | 0.31 | 0.31418 | 0.314 | 0.3116 | 0.317152 | 0.321209 | 0.3251 | 0.33759 | 0.311441 | 0.315 | 0.322709 | 0.325525 | 0.342915 | 0.343962 | 0.276784 | 0.32948 | 0.321684 |
| $f 1$ | 0.521847 | 0.521015 | 0.52462 | 0.52056 | 0.534023 | 0.52592 | 0.5212 | 0.5253 | 0.5275 | 0.5314 | 0.525068 | 0.525 | 0.531788 | 0.536775 | 523929 | 460 | 0.573043 |
|  | 0.47815 | 0.4 | 0.475371 | 0.47943 | 0.46597 | 0.47407 | 0.4787 | 0.474 | 4724 | 68 | 0.4749 | 0.474 | 0.4682 | 0.463225 | 476 | 0.53 | 0.426957 |

$$
\begin{align*}
& \begin{array}{cccccc}
c_{11} & & & & & \\
\boldsymbol{D}_{12} & & & & & \\
\boldsymbol{D}_{1} & \cdots & \boldsymbol{D}_{j} & \cdots & \boldsymbol{D}_{n} \\
c_{11} \cdots c_{1 m_{1}} & \cdots & c_{j 1} \ldots c_{j m_{j}} & \cdots & c_{n 1} \ldots c_{n m_{n}}
\end{array} \\
& \boldsymbol{W}=\left(\boldsymbol{T}_{C}^{\alpha}\right)^{\prime}=\begin{array}{cccccc}
\boldsymbol{D}_{1} & \vdots \\
\vdots & \boldsymbol{D}_{i 1} & c_{i 2} \\
\vdots & \vdots \\
c_{i 2} \\
{ }^{2} & c_{i m_{i}}
\end{array}\left[\begin{array}{ccccc}
\boldsymbol{W}^{11} & \cdots & \boldsymbol{W}^{i 1} & \cdots & \boldsymbol{W}^{n 1} \\
\vdots & & \vdots & & \vdots \\
\boldsymbol{W}^{1 j} & \cdots & \boldsymbol{W}^{i j} & \cdots & \boldsymbol{W}^{n j} \\
\vdots & & \vdots & & \vdots \\
\boldsymbol{W}^{1 n} & \cdots & \boldsymbol{W}^{i n} & \cdots & \boldsymbol{W}^{n m}
\end{array}\right] \tag{18}
\end{align*}
$$

## Step 9: formation of weighted super matrix

In order to form a weighted super matrix, the normalised full-relation $T_{D}^{\alpha}$ is transposed and is multiplied by un-weighted super matrix.

$$
\boldsymbol{W}^{\alpha}=\left(T_{D}^{\alpha}\right)^{\prime} \times \boldsymbol{W}=\left[\begin{array}{ccccc}
t_{D}^{\alpha 11} \times \boldsymbol{W}^{11} & \cdots & t_{D}^{\alpha i 1} \times \boldsymbol{W}^{i 1} & \cdots & t_{D}^{\alpha n 1} \times \boldsymbol{W}^{n 1}  \tag{19}\\
\vdots & & \vdots & & \vdots \\
t_{D}^{\alpha 1 j} \times \boldsymbol{W}^{1 j} & \cdots & t_{D}^{\alpha i 1} \times \boldsymbol{W}^{i 1} & \cdots & t_{D}^{\alpha n j} \times \boldsymbol{W}^{n j} \\
\vdots & & \vdots & & \vdots \\
t_{D}^{\alpha 1 n} \times \boldsymbol{W}^{1 n} & \cdots & t_{D}^{\alpha i n} \times \boldsymbol{W}^{i n} & \cdots & t_{D}^{\alpha n n} \times \boldsymbol{W}^{n n}
\end{array}\right]
$$

In order to form a weighted super matrix, the normalised full-relation $T_{D}^{\alpha}$ is transposed and is multiplied by un-weighted super matrix.

$$
\begin{equation*}
\boldsymbol{W}^{\alpha}=\left(T_{D}^{\alpha}\right)^{\prime} \times \boldsymbol{W} \tag{20}
\end{equation*}
$$

First, $\left(T_{D}^{\alpha}\right)^{\prime}$, which is reverse of the matrix $T_{D}^{\alpha}$ will be obtained as follows, Table 16.
Table 16 Transpose of the full-relation matrix

| $\left(T_{D}^{\alpha}\right)^{\prime}$ | $A$ | $B$ | $C$ | $D$ | $E$ | $F$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| A | 0.172852 | 0.177999 | 0.174273 | 0.18447 | 0.183359 | 0.178965 |
| B | 0.179414 | 0.175284 | 0.188943 | 0.175946 | 0.181914 | 0.181222 |
| C | 0.149387 | 0.155425 | 0.14278 | 0.146669 | 0.145323 | 0.152104 |
| D | 0.165343 | 0.165363 | 0.165287 | 0.164008 | 0.164523 | 0.165039 |
| E | 0.171732 | 0.169881 | 0.172659 | 0.166448 | 0.165961 | 0.172265 |
| F | 0.161271 | 0.156048 | 0.156058 | 0.162459 | 0.15892 | 0.150405 |

Table 17 Un-weighted super matrix

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| a | 0.048987 | 0.060434 | 0.060161 | 0.057168 | 0.056332 | 0.057017 | 0.05778 | 0.05727 | 0.05615 | 06135 | 0.06042 | 0.061492 | 0.058878 | 0.058708 | . 059793 | 0.059119 | .060 |
| a2 | 0.0621 | 0.050754 | 0.061895 | 0.059438 | 0.059878 | 0.05921 | 0.05855 | 0.058448 | 0.058672 | 0.062579 | 0.062697 | 0.062151 | 0.06244 | 0.061839 | 0.061085 | 0.061254 | 0.062786 |
| a3 | 0.061765 |  |  |  |  |  | 0.05793 |  |  |  |  |  |  |  |  |  |  |
| b1 | . 04 | 0.052312 | 0.052636 | 0.044349 | 0.056212 | 0.053682 | 0.055313 | 0.055724 | 0.056034 | 0.053193 | 0.053333 | 0.053513 | 0.053982 | 0.054375 | 0.05445 | 0.052816 | 0.053988 |
| b2 | 0.0 | 0.064615 | 0.065097 | 0.066787 | 0.055214 | 0.06825 | 0.067886 | 0.066829 | 0.068034 | 0.061731 | 0.060805 | 0.06177 | 0.0643 | 06 | 0.064826 | 0.065345 | 0.065078 |
| b3 | 0.06536 |  |  |  |  | 0.0533 |  |  |  | 0, |  | 06664 | 063632 |  |  | 06306 |  |
| cl | 0.04 | 0.046846 | 0.046385 | 0.051955 | 0.052194 | 0.051418 | 0.041238 | 0.055925 | 0.0 | 0.0493 | 0.048534 | 0.048356 | 0.048202 | 0.04 | 0.048089 | 0.048856 | 0.050473 |
| c2 | 0.03785 | 0.0378 | 0.0373 | 0.04082 | 0.0405 | 0.042087 | 0.0455 | 0.03173 | 0.039219 | 0.0388 | 0.0391 | 0.037049 | 0.03748 | . 03692 | 0.037683 | 0.038708 | 0.0399 |
| c3 | 0.06 | 0.064647 | 0.065648 | 0.06264 | 0.06269 | 0.06192 | 0.055986 | 0.0 | . 05 | 0.058473 | 0.059032 | 264 | . 596 | 0.062 | 0.0 | 0.064541 | 0.061695 |
| d1 | 0.05427 | 0.05317 | 0.052961 | 0.05488 | 0.05441 | 0.053739 | 0.05502 | 0.05569 | 0.054779 | 0.047304 | 0.05868 | 0.059218 | 0.05411 | 0.055222 | 0.053649 | 0.054113 | 0.0554 |
| d2 | 0.05037 | 0.0511 | 0.0509 | 0.0520 | 0.0524 | 0.051 | 0.0527 | . 0516 | , | 0.0559 |  | 0537 | , 051 |  | 51289 |  |  |
| d3 | 6069 | 0.0610 | 0.061 | . 584 | 0.058457 | 059 | 0.0575 | 0.0 | 0.05 | 0.060 | 0.0606 | 0.051 | . 058 | 0.058134 | 0.0595 | 0.058738 | 0. 05 |
| el | 0.059714 | 0.06028 | 0.060434 | 0.0607 | 0.06027 | 0.059912 | 0.0626 | 013 | 0.061856 | 0.060159 | 0.059247 | 0.058141 | 0.051734 | 0.060891 | 0.062753 | . 06078 | 0.062381 |
| e2 | 0.05733 | 0.057497 | , | 0.056165 | 0.055732 | 0.055401 | 0.053886 | 0.054239 | 0.05703 | 0.053834 | 0.053486 | 0.05 | 0.057317 | 0.047986 | 0.057273 | 0.054727 | 0.05446 |
| e3 | 0.05 | 0.0 | 0.054006 | 0.052937 | 0.053878 | 0.0545 | . 561 | 0.058289 | 0.053773 | 0.0524 | 0.053 | 0.054183 | 0.05691 | 0.057 | 0.045935 | 0. 056758 | 0.055 |
| $f 1$ | 0.08415 | 0.084025 | 0.0846 | 0.08123 |  | 0.0820 | 0.0813 |  | 0.082332 | 8634 | 0.085302 | 0.085306 | 84512 | 85304 | 0.083263 | 069278 | 0.086188 |
| f2 | 0.0 | 0.077247 | 0.076664 | 0.074816 | 0.072715 | 0.073978 | 0.074714 | 0.074068 | 0.073726 | 0.076119 | 0.077 | 0.077 | 0.074408 | 0.073616 | . 075 | 0.081127 | 0.064216 |

And weighted super matrix will be extracted as follows, Table 17.
Table 18 Calculation of the weights of criteria and sub-criteria

| Main criteria | Weights of main criteria | Priority | Sub-criteria | Code related to sub-criteria | Weights of sub-criteria | Priority |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| A: Technical empowerment | 0.178634 | 2 | Logistics equipment | $\mathrm{a}_{1}$ | 0.058332 | 10 |
|  |  |  | Expertise in specific industry and experience | $\mathrm{a}_{2}$ | 0.060392 | 6 |
|  |  |  | Secure electronic data exchange | $\mathrm{a}_{3}$ | 0.059911 | 8 |
| B: Productive empowerment | 0.180222 | 1 | Communication with other logistics providers | $\mathrm{b}_{1}$ | 0.053128 | 14 |
|  |  |  | Speed and quality control and considering standards | $\mathrm{b}_{2}$ | 0.064514 | 3 |
|  |  |  | Flexibility and innovation | $\mathrm{b}_{3}$ | 0.06258 | 4 |
| C: Strategic empowerment | 0.14878 | 6 | Senior management support | $\mathrm{c}_{1}$ | 0.048743 | 16 |
|  |  |  | Systemic and futuristic look | $\mathrm{c}_{2}$ | 0.03886 | 17 |
|  |  |  | Introduction to legal and tax laws | $c_{3}$ | 0.061177 | 5 |
| D: Financial empowerment | 0.164928 | 4 | Financial stability | $\mathrm{d}_{1}$ | 0.054477 | 12 |
|  |  |  | Attract investor | $\mathrm{d}_{2}$ | 0.051614 | 15 |
|  |  |  | Reduced operational costs | $\mathrm{d}_{3}$ | 0.058838 | 9 |
| E: Marketing and sales empowerment | 0.169766 | 3 | Maintaining longterm customer relationships | $\mathrm{e}_{1}$ | 0.060131 | 7 |
|  |  |  | Geographic coverage and new markets | $\mathrm{e}_{2}$ | 0.055218 | 11 |
|  |  |  | Skills in fair negotiations | $e_{3}$ | 0.054417 | 13 |
| F: staff empowerment | 0.157636 | 5 | Organisational learning and training of parties | $\mathrm{f}_{1}$ | 0.082706 | 1 |
|  |  |  | Safety and health of employees | $\mathrm{f}_{2}$ | 0.07493 | 2 |

## Step 10: limited weighted super matrix

We limit the weighted super matrix through exponentiation to a large number $Z$, until the super matrix converge and reach stability. This matrix is convergent after three times. The output of this step will be the effective DANP weights.

$$
\begin{equation*}
\lim _{Z \rightarrow \infty}\left(W^{\alpha}\right)^{Z} \tag{21}
\end{equation*}
$$

## Step 11: calculation of the weights of criteria and sub-criteria

Thus, the limit number in the first row is the weight first sub-criteria and the limit number in the row 2 is the weight of the second sub-criteria and the limit number in the $n^{\text {th }}$ row is the weight of the $n^{\text {th }}$ criteria. In order to calculate the weight of the criteria, it is necessary to sum up the weight of the corresponding sub-criteria. On the basis of a finite matrix, we can obtain the weight of the following criteria with finite-element numbers, and, by summing up the weight of sub-criteria of each major criteria, weights of the main criteria are also determined.

Thus, the enablers which have the highest weight in empowering 3PL consist of: manufacturing enablers, technical enablers, marketing and sales enablers, financial enablers, human resource enablers and strategic enablers, which are distinguished by the weight of the sub-criteria, Table 18.

## 5 Conclusions, limitation and further research direction

Iran has a great potential in the field of logistics as an international gateway. Identifying the enablers of 3PL providers, as well as identifying the needs and expectations of neighbours and international markets, Iran can improve its logistics performance, thus, helping consolidate its position and highlighting its role in global affairs on improving the political, economic and cultural situation. Improving the awareness level of the importance of logistics in recent years has led to more or less initiatives to develop logistics in countries and leading companies in the world, including the emergence of 3PL companies and extending public acceptance of them. Based on the obtained data, it is possible to improve the third-party logistics performance by providing accurate planning and considering the network relations of the enablers and provide the ground for the development of the enabled 3PL. Paying attention to factors such as technical and production enablers are among the most important criteria. It is also necessary to create the prospect of this breakthrough in the organisation, with emphasis on organisational learning and training, focusing on standards and quality control, and maintaining safety and health of employees, which are among the most important sub-criteria for empowerment.

With the help of relation-impact diagram on technical enablers, it can be concluded that logistics equipment and expertise in a particular industry are potentially influential enablers. Because the vertical axis has a positive impact on the secure exchange of data on. Secure electronic exchange of data also interacts with two other variables and is more relevant to other variables. Jung (2017) also confirms that the customisation and customisation services with a weight of 0.482 are one of the most important capabilities of logistics companies analysed by hierarchical analysis method. In the diagrams of the
productive enablers, the relationship with other logistical providers is influential and important, which can have a significant impact on the speed, quality control and considering manufacturing standards variables. Also, flexibility, innovation and personalisation are variables that are affective and have a great interaction with other variables. Osterwalder (2017) suggests that the secure exchange of data and the use of electronic foundation data structures can lead to improved quality control, and attention to standards is one of the three most important factors in choosing 3PL companies. In the strategic enablers diagram, two senior management support and familiarity with legal, insurance, and tax laws variables are one of the influential enablers that affect the systemic and prospective look. Meanwhile, the variable 'familiarity with legal and tax laws' has the most interaction and relevance with other variables. Anderson et al. (2011) suggest that, in order to implement the outsourcing process, senior management support (factor loading $=0.73$ ) in the structural equation modelling has a significant impact on the quality of outsourcing. In the financial enabler diagram, financial stability and capital absorption are recognised as influential enablers, and the reduction of production costs is one of the most influential variables. On the other hand, financial stability is one of the enablers which have the most relation and interaction with other variables. Malakootinejad (2016) also in his PhD thesis on the regression method has shown that financial stability and the attraction of capital can lead to a reduction in the price of services provided. In the marketing and project management enablers, it has been shown that geographic coverage and skill in fair negotiations are influential enablers, and the variable of maintaining long-term interactions with the client is one of the most affective variables. Also, geographic coverage and access to new markets are of the enablers that interact more with other variables. Geographic coverage with a rating of 2 and a weight of 0.172 and maintaining long-term customer relationship with customer rating of 5 and a weight of 0.042 are among the seven identified factors in corporate empowerment (Samar and Dubey, 2014). In the human resources enabler diagram, organisational learning and employee training of the parties are influential enablers, and the variable of safety and health of employees are known as affective variables. Organisational learning and staff training also interact more with other variables. Jung (2017) also confirms that the education and training of workers with a weight of 0.282 and health and safety are also 0.4 weight percent of the important capabilities of logistics companies that can be considered in assessing the social sustainability of 3PL companies. At the end of this article, a few suggestions are presented to organisations: to identify industries and logistics affairs that the company can succeed in. Develop and improve required expertise and document knowledge in accordance with knowledge management. Improve hardware facilities according to customer requirements

Adopt a purchasing strategy or integration with other logistics companies, especially with specialists in providing value added services in different industries in order to acquire new logistics capabilities.

Membership of logistics parks in border areas and industrial zones in order to connect with manufacturing companies and logistics enterprises. Considering the importance of long-term relationship with the client, it is suggested that CRM software and a team of psychologists and specialists in management affairs be used in order to maintain long-term customer relationship with the client. Increase flexibility in demand and administrative applications (internal flexibility) and increase flexibility in providing services and production, with increasing the number of logistics equipment and up-to-date specialised knowledge (external flexibility).

One of the limitations of this research is the lack of information resources in the field of 3PL companies, especially the lack of Latin and Persian books in this field. The second limitation, which is particularly visible in Iran, is the lack of 3PL companies across the country. Most 3PL companies in Iran are traditionally engaged in this field, and are the second generation of 3PL companies perhaps. The next limitation is the finding of experts in this field in Iran, which unfortunately had only a limited number of responses in this field and were able to interview and complete the questionnaire.

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