Analyzing critical success factors for a successful transition towards circular economy through DANP approach

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Received 16 September 2019
Revised 5 December 2019
31 December 2019
Accepted 31 December 2019

Abstract

Purpose – The successful transition towards the circular economy is a requirement of this technological era. The objective of this study is to identify critical success factors behind the successful transition to the circular economy.

Design/methodology/approach – A systematic literature review and experts' inputs are used to identify the major critical success factors of a successful transition towards a circular economy. Further, DANP is applied to discover the interrelationships among the critical success factors dimensions by analyzing causal relations between the relevant critical success factors. Additionally, the ranking of significant critical success factors for the successful transition towards the circular economy is determined.

Findings – This study has used the DANP methodology to understand the relationships among the five dimensions and the twenty-two critical success factors and identified the key influencing critical success factors through their global weights. Research findings suggest that "vision regard to a circular economy" has the highest weights, followed by "financial sustainability" which is regarded as the most important CSF.

Research limitations/implications – The outcomes of this work may help organizations on issues related to the transition of the linear economy towards circular economy, in understanding the degree of importance of the each critical success factors, based on which the organizations can formulate an effective strategy to systematically emphasize critical success factors as per their importance for the successful transition towards circular economy.

Originality/value – This study tries to explore and analyze critical success factors of the transition from the linear economy to a circular economy. Further, the finding of this study provides deeper insights into academia and mangers that helps to formulate their action plan for moving towards the circular economy.

Keywords Circular economy, Critical success factors, DANP, DEMATEL, Transition, Sustainability

Paper type Research paper

1. Introduction

The world biodiversity is declining, and the world economy is expected to quadruple by 2050 (Wijkman and Skånberg, 2017). Resources like fossil fuels, metals, fertile land, and water are increasingly hard to get for the massively increasing population. The current trend in the economy is linear and is generally known as "take-make-use-dispose" model (Ghisellini *et al.*, 2016), which is continuing from the start of the industrial revolution (Ness, 2008). This linear model is not working well as the circumstances have changed. The Circular Economy (CE), primarily focusing on the reuse of new materials, can be the best alternative for the linear economic model (Singh and Ordoñez, 2016). "CE is a general term covering all activities that reduce, reuse and recycle materials in production, distribution, and consumption processes" (Blomsma and Brennan, 2017). The concept of "closing material loops" in the CE aims for the sensible utilization of natural resources and the reducing reusing and recycling of biological materials to extricate their maximum benefits with the least consumption (Jeng *et al.*, 2019). The idea of CE is eminent in the scholarly world, industries, and government, but its

Management of Environmental Quality: An International Journal
Vol. 31 No. 3, 2020
pp. 505-529
© Emerald Publishing Limited
1477-7835
DOI 10.1108/MEQ-09-2019-0191

incorporation is still limited. Today only certain regions of a few countries such as China, Japan, Netherland, Germany, the United Kingdom are adopting CE. The shifting from a linear economy towards the CE is not smooth, and various hindrances come in the way for a successful transition towards CE.

Progress towards a CE involves significant changes in all the processes involved in the development of a product (Almut *et al.*, 2016; Nakajima, 2000). In the quest for the potential business, industrial organizations are effectively engaging the progress from linearity to circularity (Nordic Council of Ministers, 2015; Tukker, 2015). The concepts of reuse, remanufacturing, and recycling are being used for and reorganized, thus accentuating the adoption benefits, projecting the primary difficulties, and uncovering the barriers to be overcome as to achieve a CE.

The elements which facilitate the successful transition towards the CE need to be acknowledged. They represent crucial areas to be focused on the successful transition towards a CE but are insufficiently studied, thus constituting a gap in the research. Based on this gap, we have framed the research question of this study:

RQ1. What are the CSFs for the successful transition towards a CE?

Based on this question, the objective of this study is:

(1) to identify the CSFs for a successful transition towards CE based on systematic literature review;

(2) to evaluate and rank the identified CSFs using DANP method;

(3) to understand the interrelationships of CSFs in the transition towards CE.

The rest of the paper is organized as follows: section 2 deals with literature review; section 3 provides the overview of the adopted research methodology; section 4 analyzes the data and reported results; section 5 discusses the results; section 6 provides the major research implications; finally, section 7 states the conclusion and future scope.

2. Literature review

2.1 Circular economy and related studies

Korhonen *et al.* (2018) defined CE as "an economy constructed from societal production-consumption systems that maximize the service produced from the linear nature-society-nature material and energy throughput flow." It can further be accomplished by utilizing closed materials streams, inexhaustible energy sources, and cascading type of energy streams. CE constrains the throughput stream to a dimension that nature endures and uses ecological system cycles in monetary cycles by regarding their natural generation rates (Korhonen *et al.*, 2018). The main objective of CE is to maximize the utility and value of the products through the processes of repairing, reusing, refurbishing, and recycling with reducing waste generation. (Merli *et al.*, 2018). The concepts of "eco-design," "cleaner production," and "waste management" are supported by the CE by limiting the resource consumption (Zhu *et al.*, 2011). The limited use of virgin resources, reduced waste generation, growth in sustainability with environmental, financial and social improvement are the objectives of the CE (Yu *et al.*, 2015).

Today CE is seen as a solution or part of the solution to the environmental, social, and resource challenges (Panigrahi *et al.*, 2019). Therefore, many researchers, industry, and government have paid more attention and several studies related to the CE and the same were reported in the literature. These studies range from manufacturing to fashion industries in the context of the (re)design, manufacturing, supply chain management, and performance evaluation (Smith *et al.*, 2017). For instance, a framework is proposed to measure the performance of a green supply chain in the context of CE (Kazancoglu *et al.*, 2018). Mangla *et al.* (2018) identified and analyzed fifteen barriers related to the effective circular supply chain management in the context of an emerging economy. They find that the lack of environmental laws and tax policies and lack of preferential tax policies is the significant barriers. A similar study is also conducted by Farooque *et al.* (2019) in the context of China and they show that weak environmental regulations and lack of market preference/pressure are significant barriers to shift towards the CE.

In order to implement the CE, Kalmykova *et al.* (2018) provide the strategies that are relevant to different parts of the supply chain. Also, the implementation of CE is discussed through the business models for the CE and operations management in the CE environment (Lopes de Sousa Jabbour *et al.*, 2019). Vlajic *et al.* (2018) focus on the reverse logistic aspect of circular supply chains to achieve sustainable business practices. Masi *et al.* (2018) consider that the transition towards a CE is in progress and face some barriers such as investment cost and lack of awareness. They advocate the adoption of CE practices related to investment recovery, customer cooperation, and green purchasing. Govindan and Hasanagic (2018) identified through systematic review drivers, barriers, and practice towards the transition to CE. The finding of this study shows that CE can be encouraged by government policies, tax reduction, and strict governance.

2.2 Critical success factors for the successful transition towards the circular economy

The CSF "is an element that is necessary for an organization to achieve its goal." According to Boynton and Zmud (1984), "CSFs are those few things that must go well to ensure success for a manager or an organization." CSFs are "the key factors/ enablers/ activities needed for the successful accomplishment of any business/ phenomenon to happen and necessary for an organization to achieve their goals" (Haleem *et al.*, 2012; Khan *et al.*, 2018). CSF represents those zones of a system that should be given continuous attention to achieved better performance (Sfakianaki, 2019). In this paper, CSFs of transition towards CE are identified and categorized into five different dimensions (see Table I).

3. Research methodology

Analyzing the CSFs for the successful transition towards the CE is an intricate Multiple-Attribute Decision Making (MADM) process. For this research, the goal is the successful transition towards CE. Thus, to fulfill this objective, CSFs of the transition towards a CE needs identification and analysis. In order to do so, initially, twenty-seven CSFs are identified through the literature review of the CE, sustainable supply chain management, and green supply chain management. After identification of twenty-seven CSFs, the list is provided to a designated expert group to validate the relevance of these CSFs. Experts suggested dropping of four CSFs that do not seem appropriate in the context of a CE and also advised merging of two of them. In this manner, twenty-two CSFs for the successful transition towards CE are finalized. Further, experts also suggested to categorize CSFs into different categories based on the nature of the CSFs, and we have incorporated the same and categorized these twenty-two CSFs into five different categories. These factors are not independent; instead, they mutually influence each other. Hence, we require a method which could also recognize the interactions between the factors.

Majority of the methods which could address the MADM problems, such as Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution

Dimensions	Critical success factor	Description	References
Organizational	A1. Management commitment and support	The management commitment and support such as proper training of the employees and suppliers have made an important influence on initiatives of organizations to implement the CE	Dubey *et al.* (2019); Stratan (2017)
	A2. Vision in regard to CE	Vision in terms of goals, objectives, targets about the CE should be clear to shift towards the CE	Pan *et al.* (2015)
	A3. Policies for CE practices	Public policies play a crucial role in creating an enabling condition (recycling policies, environmental laws, etc.) for a CE to develop and bloom	Maitre-Ekern and Dalhammar (2016); Genovese *et al.* (2017)
	A4. Business models	The circular business models will help the organizations in increasing differentiation, decreasing cost to serve and own, generating new revenues, and reducing risks and their impact on the rules of resource supply and demand	Mangla *et al.* (2018). Stratan (2017)
Economical	B1. Financial sustainability	Financial sustainability is the proper management of risks and effectively using financial resources and maximizes the impact	Stratan (2017)
	B2. Capital investments	Capital investment refers to funds invested in a firm or enterprise for securing its business ideas and expanding their businesses for the future and lasting use	Wyman (2017)
	B3. Reuse of resources	CE aims at prosperity, and a possible increase in prosperity without this being at the expense of finite resources. The success of a CE is measured mainly by the re-use of resources.	Stratan (2017)
	B4. Remanufacturing/ reuse cost	Remanufactured/recycled products should be cheaper than virgin materials	Lieder and Rashid (2016); Shahbazi *et al.* (2016)

(*continued*)

Table I.
Critical success factors for the successful transition towards CE with dimensions

Dimensions	Critical success factor	Description	References
Technological	C1. Methods, indicators, and monitoring	The circularity indicators methods and monitoring offer companies with a methodology and tools to measure the performance of a product or company in a circular economic perspective	MacArthur (2015)
	C2. Integration of CE with digital technology	A digital platform can enable rapid development of innovative products and services collaboratively. Digital tools can be the catalyst for optimizing manufacturing and business processes across an enterprise to gear up for the CE	Bressanelli *et al.* (2018); Pagoropoulos *et al.* (2017)
	C3. The expertise of key people in their respective fields	For the successful transition towards a CE, the people involved in the different areas of the CE need to be expert in their respective fields.	Stratan (2017)
	C4. Technical know-how and skill development	Organizational skills and know-how are necessary for a business manager to grow the business in the CE. The technical and managerial skill of the process standardization and workflow is the prime importance to develop businesses in the CE	Van Weelden *et al.* (2016)
	C5. Ability to innovate	"Sustainable innovation is the engine for future growth and is a catalyst for revolutionizing the art of business." The shifting from linear to circular business models will depend on the ability of an organization to innovate.	Stratan (2017).
	C6. Technological resources for CE implementation	The complexity in the products makes it necessary for using technological resources for effective and efficient recovery and reuse of products	Genovese *et al.* (2017), Maqbool *et al.* (2020)
	C7. Quality preservation of reused material	Using the up-cycling process in the CE for enhancing the quality of the recycled products	Singh and Ordoñez (2016), Ghisellini *et al.* (2016)

(*continued*)

Table I.

Dimensions	Critical success factor	Description	References
Environmental	D1. Eco-innovation	Eco-innovation is regarded as a key factor in the shifting from a linear to a CE	De Jesus and Mendonna, 2017
	D2. Eco-design	Eco-design is considered as a catalyst to switch from linear economy to a CE. Products are required to be designed both for circular loops and for revenue generation	Moreet *al.* (2016)
	D3. Cleaner production	CE involves practices which when follows to improve the ecological efficiency	Ghisellini *et al.* (2016), Lieder and Rashid (2016)
	D4. Legal and regulatory environment	Environmental protection is among the objectives of the CE for which it includes regulatory law. Need to designing of laws for a transition to sustainability	Stratan (2017)
Social	E1. Public awareness of CE	Inspire and gather people to raise awareness of the CE, and opportunities using proven techniques for innovation and design	Stratan (2017); Lieder and Rashid (2016); MacArthur (2015)
	E2. Employment generation	CE possess the potential to generate employment at the local level	Schiller *et al.* (2017); Ilić and Nikolić (2016)
	E3. Consumer perception towards used product	Consumers usually have negative perceptions about the remanufactured products and show reluctance in buying the refurbished products	Ghisellini *et al.* (2016); Van Weelden *et al.* (2016)

Table I.

(TOPSIS), VlseKriterijumska Optimizacija I KompromisResenje (VIKOR) methods, assume that these factors are independent of each other (Haleem *et al.*, 2019; Asees Awan, and Ali, 2019). Baykasoğlu *et al.* (2013) claimed that this assumption is not realistic for many practical cases. Therefore, the Analytic Network Process (ANP) seemed suitable for this study in order to find the dependence and feedback among the criteria. However, the ANP method assumes that the network structure of the problem is known, and the factors have equal weights. Yang *et al.* (2008) stated that the network structure is often unknown, and the weight of each element is different. Moreover, the comparison matrices of ANP are too many and complicated.

ANP has become a significant approach for addressing the multiple-attribute decision-making problems successfully, for example, policy evaluation problems, risk analysis, and factor research problems. This study uses the integration of DEMATEL and ANP methods. DEMATEL is employed to obtain the influence levels of each factor over other factors (Khan *et al.*, 2019). This is in addition to the detection of complex relationships and developing of NRM for the criteria. The NRM is developed to show the significant relationship among the factors. The vertices of this NRM show the factor and arcs represent the directional relationship between these factors. The relationship between the factors can be unidirectional or bidirectional. The direction of the arrow from the *i*th factor to the *j*th factor shows the influence of the "factor *i*" on "factor *j*" (Khan *et al.*, 2018). This means that in the case of unidirectional relationship, the influential factor occurs at the tale side of the arrow while influenced factor lies on the head side. The bidirectional relationship is shown with the help of a bidirectional arrow (↔). If arc exists between the factors it represents, then there is significant relationship among factors. Figure 1 shows the proposed research framework.

3.1 DANP method

After the identification of the CSFs, we developed an appropriate questionnaire, which was sent to experts. Responses are collected about the effect of one factor over another. The questionnaire comprised of two pairwise comparison matrices, one matrix for the dimensions which are the organizational, economic, technological, environmental, and social and second matrix for the factors (CSFs) of successful transition towards CE. The experts were asked first to evaluate the relative importance between the two factors using the five-point linguistic scale (i.e., influence to high influence) to evaluate their influential strength. The expert's input is used to determine the degrees of influence of each criterion. This data will be used to build the NRM. The steps involved in the DANP method are as follows:

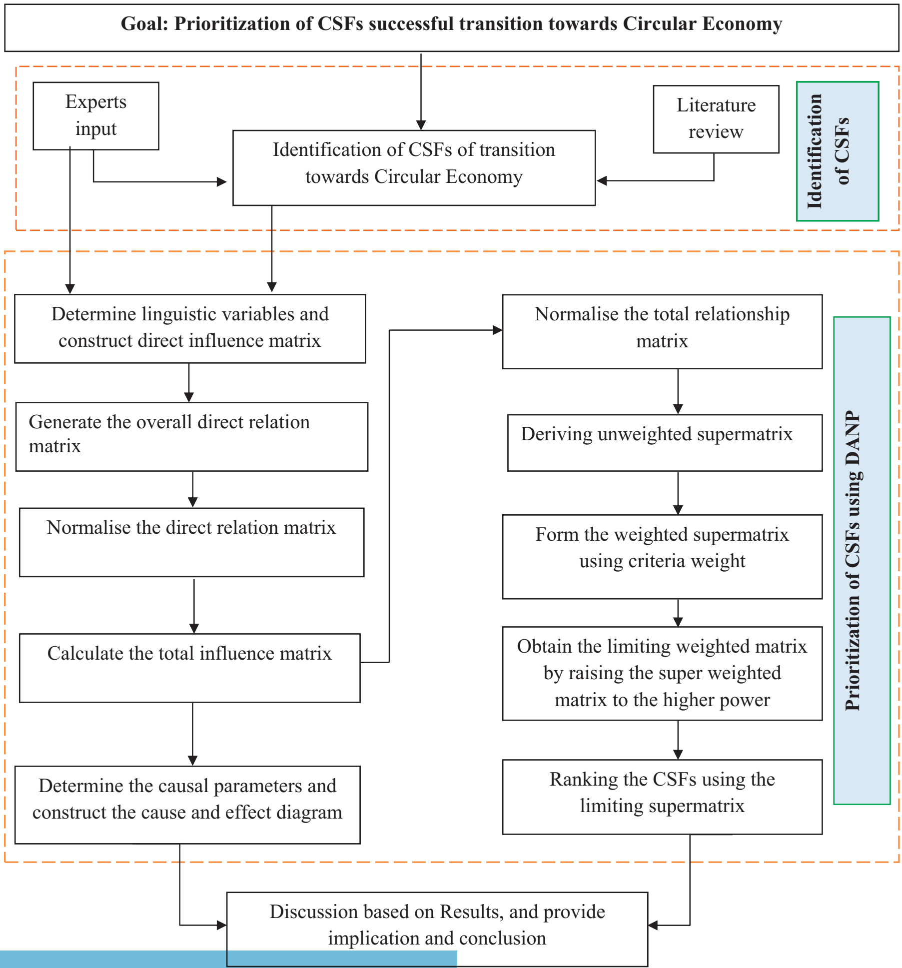

Figure 1. Proposed research framework for this study

Step 1: Generation of the matrix for direct influence

The matrix acquired from the experts indicates the influence of factor i on factor j, represented by $x^k = [x^k_{ij}]$, where k is the kth expert.

Step 2: Generation of overall direct relation matrix

The average matrix $A = [a_{ij}]$ and can be calculated using N experts from the expression (1)

$$a_{ij} = \frac{\sum_{k=1}^{N} x_{ij}^{k}}{N} \tag{1}$$

Step 3: Generation of normalized initial direct relation matrix B from expressions (2) and (3)

$$B = A.S \tag{2}$$

$$\text{where } S = \frac{1}{max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}} \tag{3}$$

Step 4: Generation of total relation matrix "T" from expression (4)

$$T = B.(I - B)^{-1} \tag{4}$$

where "I" is the identity matrix.

$$T_D = \begin{array}{c} \\ \\ D_1 \\ \\ \\ D_j \\ \\ \\ D_m \\ \end{array} \begin{array}{c} C_{11} \\ C_{12} \\ \vdots \\ C_{1n_1} \\ C_{j1} \\ C_{j2} \\ \vdots \\ C_{jn_2} \\ C_{m1} \\ C_{m2} \\ \vdots \\ C_{mm_n} \end{array} \overset{\begin{array}{ccc} D_1 & D_j & D_m \\ C_{11} \cdots C_{1n_1} & C_{j1} \cdots C_{jn_2} & C_{m1} \cdots C_{mm_n} \end{array}}{\begin{bmatrix} T_D^{11} & \cdots & T_D^{1j} & \cdots & T_D^{1m} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ T_D^{j1} & \cdots & T_D^{jj} & \cdots & T_D^{jm} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ T_D^{m1} & \cdots & T_D^{mj} & \cdots & T_D^{mm} \end{bmatrix}} \tag{5}$$

Step 5: Calculation of NRM based parameters from the expressions (6) and (7)

$$R_i = \sum_{j=1}^{n} t_{ij} \quad \text{for all } i \tag{6}$$

$$C_i = \sum_{i=1}^{n} t_{ij} \text{ for all } j \tag{7}$$

The row sum of the ith row elements of matrix T is represented by R_i as shown in expression (6) which signifies the influence of factor "i" on the other factors. Similarly, the column sum of the jth column elements t_{ij} of matrix T is represented by C_i is shown in expression (7), and it signifies influence on factor j by other factors. The difference $(R_i - C_i)$ demonstrates the net influence the factor i adds to the system (Sufiyan *et al.*, 2019).

Moreover, if "$R_i - C_i$" is positive, factor i is a net cause, while factor i is a net receiver if "$R_i - C_i$" is negative and "$R_i + C_i$" the prominence of factor i. Based on the value of the "$R + C$" and "$R - C$", the network relation map is developed. Factors having the positive values of "$R - C$" are classified as the influential group, while the factors having negative values of the "$R - C$" is classified as an influenced group. The individual influence of one factor over another factor is represented by the arrow in the network relationship matrix. In order to develop the individual influence of one factor over another factor, a threshold value is chosen. This threshold value is computed by the average value of the total relation matrix and is obtained for dimensions and factor level. When the value of an element of the "total influence matrix" exceeds the threshold value, then they should be plotted with arrows in an NRM. This signifies the directional relationships.

Step 6: Generation of normalized total relation matrix

The total influence matrix includes T_D based on dimensions as well as T_C based on criteria. Normalizing T_D and T_C by Equations (8)–(11), $T_D^{\ norm}$ and $T_C^{\ norm}$ can be derived.

3.1.1 Normalization of TD.

$$T_D^{norm} = \begin{bmatrix} \frac{t_D^{11}}{r_1} & \cdots & \frac{t_D^{1j}}{r_1} & \cdots & \frac{t_D^{1m}}{r_1} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \frac{t_D^{i1}}{r_i} & \cdots & \frac{t_D^{ij}}{r_i} & \cdots & \frac{t_D^{im}}{r_i} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \frac{t_D^{m1}}{r_m} & \cdots & \frac{t_D^{mj}}{r_m} & \cdots & \frac{t_D^{mm}}{r_m} \end{bmatrix} \tag{8}$$

Where, $r_1 = \sum_{j=1}^{m} t_D^{1m}$; $r_i = \sum_{j=1}^{m} t_D^{ij}$; $r_m = \sum_{j=1}^{m} t_D^{mm}$

The normalized total influence matrix will be

$$T_D^{norm} = \begin{bmatrix} t_D^{norm11} & \cdots & t_D^{norm1j} & \cdots & t_D^{norm1m} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ t_D^{normi1} & \cdots & t_D^{normij} & \cdots & t_D^{normim} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ t_D^{normm1} & \cdots & t_D^{normmj} & \cdots & t_D^{normmm} \end{bmatrix} \tag{9}$$

3.1.2 Normalization of T_c. The total relation matrix (T_c) is grouped into clusters according to some dimensions, e.g., in our study; there are five dimensions; accordingly, five clusters are made column-wise. Each element in a cluster is divided by the row sum of its cluster as shown in expression (10).

$$
\begin{array}{c}
 \\
T_c = \begin{array}{cc}
 & C_{11} \\
 & C_{12} \\
D_1 & \vdots \\
 & C_{1n_1} \\
 & C_{j1} \\
 & C_{j2} \\
D_j & \vdots \\
 & C_{jn_2} \\
 & C_{m1} \\
 & C_{m2} \\
D_m & \vdots \\
 & C_{mm_n}
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{ccc} D_1 & D_j & D_m \\ C_{11} \dots C_{1n_1} & C_{j1} \dots C_{jn_2} & C_{m1} \dots C_{mm_n} \end{array} \\
\begin{bmatrix}
\frac{t_C^{11}}{r_{11}} & \cdots & \frac{t_C^{1j}}{r_{1j}} & \cdots & \frac{t_C^{1m}}{r_{1m}} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
\frac{t_C^{i1}}{r_{i1}} & \cdots & \frac{t_C^{ij}}{r_{ij}} & \cdots & \frac{t_C^{im}}{r_{im}} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
\frac{t_C^{m1}}{r_{m1}} & \cdots & \frac{t_C^{mj}}{r_{mj}} & \cdots & \frac{t_C^{mm}}{r_{mm}}
\end{bmatrix}
\end{array}
\tag{10}
$$

Step 7: Generation of unweighted supermatrix (W)

The matrix $T_C{}^{norm}$ is obtained after the normalization of the total influence matrix. By transposing $T_C{}^{norm}$, we obtain the unweighted supermatrix as shown in expression (11).

$$
W = (T_C^{norm})' = \begin{array}{cc}
 & C_{11} \\
 & C_{12} \\
D_1 & \vdots \\
 & C_{1n_1} \\
 & C_{j1} \\
 & C_{j2} \\
D_j & \vdots \\
 & C_{jn_2} \\
 & C_{m1} \\
 & C_{m2} \\
D_m & \vdots \\
 & C_{mm_n}
\end{array}
\begin{array}{c}
\begin{array}{ccc} D_1 & D_j & D_m \\ C_{11} \dots C_{1n_1} & C_{j1} \dots C_{jn_2} & C_{m1} \dots C_{mm_n} \end{array} \\
\begin{bmatrix}
w^{11} & \cdots & w^{j1} & \cdots & w^{m1} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
w^{1j} & \cdots & w^{ij} & \cdots & w^{mj} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
w^{1m} & \cdots & w^{im} & \cdots & w^{mm}
\end{bmatrix}
\end{array}
\tag{11}
$$

Step 8: Generation of the weighted matrix (W*)

A weighted supermatrix, which is improved traditional ANP by using equal weights to make it appropriate for the real world, is generated by multiplying the unweighted matrix (W) with the transpose of $T_D{}^{norm}$ shown in equation (12).

$$W^* = (T_D^{norm})' \times W = \begin{bmatrix} t_D^{norm11} \times w^{11} & \cdots & t_D^{normj1} \times w^{j1} & \cdots & t_D^{normm1} \times w^{m1} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ t_D^{norm1j} \times w^{1j} & \cdots & t_D^{normji} \times w^{ji} & \cdots & t_D^{normmj} \times w^{mj} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ t_D^{norm1m} \times w^{1m} & \cdots & t_D^{normjm} \times w^{jm} & \cdots & t_D^{normmm} \times w^{mm} \end{bmatrix} \quad \textbf{(12)}$$

Step 8: Obtaining the criteria weight

The global priority vector, which defines the influential weights $w = (w1, \ldots, wj, \ldots, wn)$ from $\lim_{g\to\infty} (w^*)^{\alpha}$ for the criteria is obtained by limiting the weighted supermatrix. The weighted supermatrix is raised to large power (α) until it converges and becomes a long-term stable super-matrix.

4. Results

This study assesses the CSFs for the successful transition towards a CE. The CSFs were identified based on extensive literature review and then finalized through the discussion with experts. In this paper, twenty-two CSFs were identified and were clustered into five dimensions shown in Table I.

4.1 Data collection for NRM

After finalizing the CSFs for the successful transition towards a CE, the questionnaire was developed and sent to experts to access the influential strength of CSFs. The questionnaire contained two pairwise comparison matrices which are expected to be filled by experts. The first comparison matrix contains the dimensions which are organizational, economic, technological, environmental, and social (refer to Table AI). The second comparison matrix contained the twenty-two CSFs. The experts were asked to give their responses about the relative importance of the two factors using the linguistic scale to evaluate their influential strength. The expert's responses are used to develop the NRM using equation (1)–(5).

4.2 Network relations map

The total influence matrix can be calculated using the expert's responses by applying equations (1–4). After that, the influence of each dimension as well as CSFs are determined and these are presented in Table II and Table III, respectively.

Table II shows the central degrees (i.e., *R*+*C*) of the five dimensions. Among the five diminutions, the organizational dimension (9.273) has the highest central degree, followed by economic dimension (8.659). The order of importance of dimensions based on central degree is organizational (9.272) > economical (8.659) > technological (8.448) > environmental (7.096) > social (6.262). Organizational, economic, and environmental dimensions have positive values of (*R*−*C*), which implies that they influence the other dimensions and can be categorized under cause group. The other dimensions, technical and social, have negative of

CSFs	*R*	*C*	*R*+*C*	*R*−*C*
A	4.858	4.413	9.272	0.445
B	4.492	4.167	8.659	0.325
C	3.648	4.8	8.448	−1.152
D	3.852	3.244	7.096	0.608
E	3.018	3.244	6.262	−0.227

Table II. The prominence (R+C) and net effect (R−C) on dimensions

CSFs	R_i	C_i	R_i+C_i	R_i-C_i
A1	0.417	0.452	0.869	−0.035
A2	0.531	0.519	1.049	0.012
A3	0.454	0.401	0.855	0.054
A4	0.472	0.503	0.975	−0.031
B1	0.328	0.306	0.634	0.022
B2	0.304	0.278	0.582	0.027
B3	0.226	0.323	0.548	−0.097
B4	0.258	0.209	0.467	0.048
C1	0.284	0.259	0.543	0.024
C2	0.27	0.277	0.547	−0.008
C3	0.277	0.235	0.512	0.042
C4	0.224	0.244	0.468	−0.02
C5	0.267	0.243	0.511	0.024
C6	0.239	0.34	0.579	−0.101
C7	0.299	0.26	0.559	0.038
D1	0.165	0.177	0.341	−0.012
D2	0.157	0.154	0.311	0.003
D3	0.193	0.164	0.357	0.029
D4	0.123	0.144	0.267	−0.021
E1	0.038	0.056	0.094	−0.018
E2	0.056	0.031	0.088	0.025
E3	0.04	0.047	0.087	−0.007

Table III.
Prominence ($R+C$) with net effect ($R-C$) on Critical Success Factors

($R-C$), which implies that they are being influenced by other dimensions and can be placed under the effect group.

Table III shows the prominence of the CSFs in which "vision in regards of CE (1.049)" has the highest central degree followed by "business models (0.975)" in the organizational dimension. Among the organizational CSFs, "vision in regard to CE" and "policies for CE practices" have positive values of ($R-C$) means they directly influence the other CSFs in the organizational dimension.

In the economic dimension, the most prominent CSF is "financial sustainability" having the highest values of ($R+C$), and the most influential is "remanufacturing/ reuse cost" with the highest value of ($R-C$) and most influenced CSF is "reuse of resources." Among the technological CSFs, "technological resources for CE implementation" is the prominent CSFs having the highest degree of prominence and "expertise of key people in their respective fields" is the most influential CSF. In the environmental dimension, "cleaner production" has the highest central value, and "legal and regulatory environment" is the most influenced CSF. In the social dimension, the highest value of "$R+C$" belongs to "public awareness of CE" and "employment generation" is among the cause factors having positive values of ($R-C$) and "public awareness" of CE and "consumer perception towards used product" are influenced CSFs having negative values of ($R-C$). Based on Table II and Table III, the network relations map is developed and shown below in Figure 2 (a)–(f).

4.3 Determining global weight of each critical success factor

Total influence matrix of demotions generated using equation (1)–(6), and it is shown in Table AI. Similarly, the total influence matrix of the CSFs is developed, and it is shown in Table AII. Further, the total influence matrix of the demotions and CSFs are transformed into normalized total influence matrix using equation (6)–(9), and the same is shown in Table AIII and AIV. The normalized total influence matrix is transposed to generate the unweighted supermatrix (W) using equation (11), and it is shown in Table AV. The weighted supermatrix is generated by multiplying the unweighted matrix (W) with the transpose of $T_D{}^{norm}$ (refer to

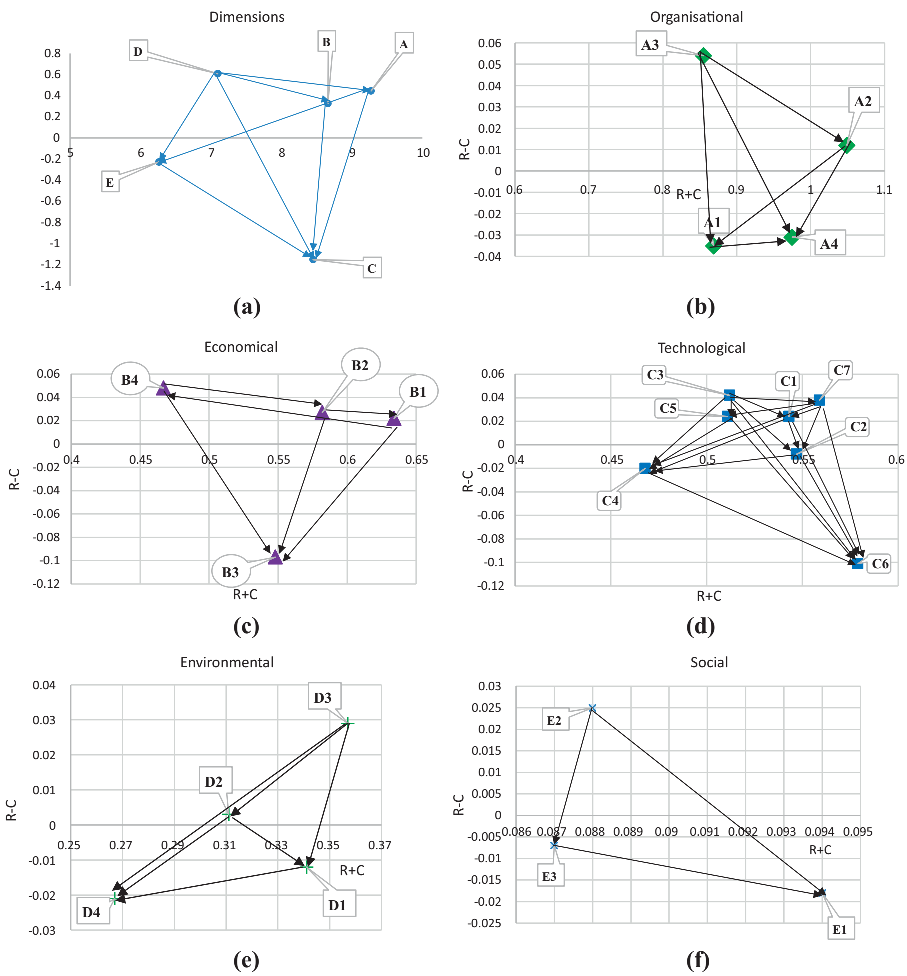

Figure 2. (a) Network Relations Map for main dimensions. (b) Network relations map for CSFs related to organizational. (c) Network relations map for CSFs related to economical. (d) Network relations map for CSFs related to technological. (e) Network relations map for CSFs related to environmental. (f) Network relations map for CSFs related to social

Table AIII) using equation (12) as shown in Table AVI. Finally, the weighted supermatrix is raised to the power of 15 to generate a stable limiting matrix (refer to Table AVII), from which we get the global weights of each CSF.

CSFs are ranked according to global weights, here vision in regard to CE has the highest weight and is followed by financial sustainability. Table IV shows the ranking order of various CSFs.

5. Discussion on results

This study focuses on the CSFs of the transition of the linear economy towards the CE. The result shows that the organizational dimension has the highest value of centrality, which implies that the organizational dimension needs to be given higher consideration for the successful transition towards the CE. Environmental, organizational, and economic dimensions have the positive values of "$R-C$" and are placed in an influential group while social and technological dimensions are having negative values and placed in the influenced group. It is evident in Figure 2 (a) that environmental, organizational, economic dimensions

Table IV.
Global and local weights of dimensions and CSFs

CSFs	Local weights based on global weights	Global weights based on DANP	Rank
A. Organizational	0.267		
A1. Management commitment and support	0.246	0.066	7
A2. Vision in regard to CE	0.277	0.074	1
A3. Policies for CE practices	0.211	0.056	12
A4. Business models	0.267	0.071	3
B. Economical	0.251		
B1. Financial sustainability	0.284	0.072	2
B2. Capital investments	0.259	0.065	8
B3. Reuse of resources	0.272	0.068	4
B4. Remanufacturing/ reuse cost	0.184	0.046	15
C. Technological	0.300		
C1. Methods, indicators, and monitoring	0.134	0.040	20
C2. Integration of CE with technology	0.142	0.043	17
C3. The expertise of key people in their respective fields	0.137	0.041	19
C4. Technical know-how and skill development	0.117	0.035	22
C5. Ability to innovate	0.127	0.038	21
C6. Technological resources for CE implementation	0.191	0.057	11
C7. Quality preservation of reused material	0.153	0.046	16
D. Environmental	0.197		
D1. Eco-innovation	0.249	0.049	13
D2. Eco-design	0.208	0.041	18
D3. Cleaner production	0.303	0.060	10
D4. Legal and regulatory environment	0.239	0.047	14
E. Social	0.195		
E1. Public awareness of CE	0.347	0.068	5
E2. Employment generation	0.342	0.067	6
E3. Consumer perception towards used product	0.311	0.061	9

are influential dimensions, and they influenced the social and technological dimensions. The environmental dimension is the most influential dimension, as it influences all the other four dimensions, while the technological dimension is the highest influenced dimensions. It implies that the management and policy planners should focus on the influencing dimensions (i.e., environmental, organizational, economic) for the successful transition towards CE.

As shown in Figure 2 (b), the most influential CSF is the "policies for CE practices" among the organizational factors. As "policies for CE practices" influence, the other three CSFs and "business model" is influenced by other remaining three CSFs. It is interesting to note that the three CSFs related to economic dimension belong to the influential group. The "financial sustainability," "capital investments," and "remanufacturing/reuse cost" influenced the "reuse of resources" as shown in Figure 2 (c). The four CSFs related to the technological dimension belong to the influential group, and the remaining three belongs to the influenced group. It is clear from Figure 2 (d) that "expertise of key people in their respective fields" is the highest influential CSFs among all the CSFs related to technological dimension. As Figure 2 (e) shows that "cleaner production" is the most influential CSF which influenced the remaining three CSFs. Figure 2 (f) represents that "employment generation" belongs to the influential group, and it influences the "public awareness of CE" and "consumer perception towards a used product."

Overall, the network relations map shows that the causal relationship among the CSFs, which specifies that "policies for CE practices," "remanufacturing/reuse cost," "expertise of key people in their respective fields," "cleaner production," and "employment generation" as the main factors to drive other CSFs in the respective dimensions. This signifies that the policymakers, including governments, must improve their policies for the successful transition and expertise knowledge should be used for the effective development in any field of the CE. Cleaner production and employment generation should be one of the main aims for the transition towards the CE.

Table IV shows the ranking of CSFs for the successful transition towards the CE. The "vision regarding CE" at the top of the list among the all identified CSFs, and this implies that there should be a clear vision in terms of goals and objectives, i.e., what and why of CE and its implementation. The "vision regarding CE" is followed by "financial sustainability" and ranked second. Financial resources play an essential role in any development which must be appropriately used for the successful transition. The emphasis should be laid on the "business models" (ranked third) and its innovation as they are regarded as the main actors in the transition towards a CE. The circular business models will help the organizations in increasing differentiation, decreasing cost to serve and own, generating new revenues and reducing risks and also their impact on the rules of resource supply and demand. The "business models" are followed by the "reuse of resources" (ranked fourth), which stresses on the effective utilization of used products. The success of the CE, or the way towards it, is, therefore, to be measured mainly by the degree of decoupling from economic activity and the re-use of resources. The "public awareness of CE" is ranked five, which implies that raising awareness among the masses will ease the transition towards the CE. The public should be encouraged and inspired by the positives in implementing the CE.

Other CSFs like "employment generation," "management commitment and support," "capital investments," "consumer perception towards used product," and "cleaner production" are ranked sixth, seventh, eighth, ninth, and tenth respectively based on global weights. A CE can be a source of employment generation by effectively incorporating the CE practices in existing organizations. The repair, reuse, and recycle approach of the CE offers the opportunity to bring back professions and jobs that had disappeared in recent times, especially in emerging economies. The leadership skills and commitment of top management has a significant impact on the initiatives of an organization towards the transaction of the linear economy into CE. Another important CSFs is "capital investment" which plays an important role in the transition as the companies making the transition to CE principles have unique financial requirements. The negative consumer perception towards the remanufactured products and their reluctance in buying the refurbished products makes it an important CSF to be focused on. Cleaner production results in ecological efficiency, influence the people to prefer the CE. It implies that these CSFs' also play a role in the successful transition towards the CE.

6. Research implications

This study provides managerial as well as theoretical implications which are presented in this section.

6.1 Managerial implications

The outcomes of this work may help organizations on issues related to the transition of the linear economy towards CE, in understanding the degree of importance of each CSF. The causal interrelationship among the CSFs assists the management to understand the influence of one CSF over others which can help in the formulation of an effective strategy for the successful transition towards CE. Further, the ranking of the CSFs might be helpful to priorities their action plan by focusing only on the highest-ranked CSF in order to move towards CE. This study might be helpful for the managers who are trying the transition towards CE in a more practical way. The findings of this research could benefit the managers interested in developing and maintaining organizations based on CE principles. Based on this study, one could work for improvements in the CSFs according to their weights, and measure the successful transition towards a CE.

6.2 Theoretical implications

The twenty-two CSFs clustered into five dimensions for the successful transition towards a CE given in this study provides theoretical insinuation for the scholarly discussion on the CE. The findings of this research will also help academia in order to develop the understanding and the importance of the transition towards the CE. Research related to the CE is in its initial stage, and this study will motivate academician to work in this area to obtain sustainability. The recognized CSFs of the transition towards CE will help academia to develop the conceptual framework for the implementation of CE practices. This study is also beneficial for academia, researchers, and industry practitioners to understand more about the transition towards CE in developing economies such as India, Chain, and other countries of south–east Asia. The framework adopted in this study can also be used for the assessment of the implementation of CE practices.

7. Conclusion, limitation, and future scope

Although the transition towards a CE has many benefits, for example, it limits the virgin resource extraction, focuses more on sustainable development and may increase the job opportunities. Therefore, the elements which facilitate the successful transition from a linear economy to CE need to be acknowledged. This study undertakes the issue of transition from a linear economy to CE. In order to do so, the CSFs for the successful transition towards the CE are identified through the literature review and finalized through the discussion with experts. Further, these CSFs are classified into five different demotions based on their similarities. After finalizing the dimensions and their associated CSFs, it was analyzed using the DANP approach. These CSFs were ranked, and the result is discussed with the experts for gaining useful insights. Some of the significant insights are provided in the discussion section. This study has used DEMATEL to describe the relationships between the five dimensions and the twenty-two CSFs and constructed an NRM. Secondly, the DANP method is used for quantitative analysis in which global weights are calculated, and the key influencing CSFs identified. The results illustrate that "vision in regard to CE" has the highest weights, followed by "financial sustainability" and are regarded as the most important CSFs for the successful transition towards CE. This study provides opportunities for advanced research in the emerging field of the CE.

The limitation of this study is that it is based on the review of the literature and experts' input. Thus, there is a chance to overlook some CFSs while conducting the literature review. Second, the prioritization is based on the expert input that might be biased towards their working level. The expert input is taken in the subjective form, which may bring some error in weights of the CSFs. This study is only limited to the analyzing the CSFs of the transition towards CE and does not consider the assessment of the adoption of CE practices or measurement of a successful transition toward CE. These limitations open the door for future research. In future, a more comprehensive literature review can be done in order to retain more CSFs. Further, fuzzy or grey theory can be integrated with the DANP method to deal with the subjectivity in the expert's input. The performance measurement of an organization towards a successful transition to CE can be assessed in future studies. From the methodological perspective, these CSFs can be evaluated by other integrated MCDM technique such as fuzzy DANP, fuzzy best-worst method, grey TOPSIS, and so on.

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Appendix

	A	B	C	D	E
A	0.902	1.110	1.244	0.801	0.801
B	1.033	0.790	1.166	0.751	0.751
C	0.865	0.811	0.743	0.614	0.614
D	0.914	0.845	0.901	0.525	0.667
E	0.70	0.610	0.745	0.553	0.410

Table AI.
Total relation matrix of Dimensions

Table AII.
Total Relations matrix of Critical success factors

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	E1	E2	E3
A1	0.069	0.128	0.095	0.126	0.097	0.097	0.112	0.070	0.075	0.072	0.078	0.064	0.065	0.091	0.066	0.066	0.062	0.086	0.065	0.046	0.042	0.040
A2	0.143	0.102	0.134	0.151	0.130	0.122	0.129	0.076	0.094	0.096	0.104	0.077	0.086	0.114	0.089	0.103	0.083	0.111	0.101	0.062	0.082	0.046
A3	0.117	0.137	0.069	0.130	0.118	0.113	0.118	0.095	0.099	0.100	0.098	0.091	0.053	0.080	0.070	0.070	0.034	0.091	0.068	0.040	0.038	0.037
A4	0.123	0.151	0.103	0.095	0.111	0.120	0.126	0.081	0.101	0.103	0.100	0.095	0.097	0.112	0.100	0.100	0.092	0.109	0.099	0.060	0.050	0.044
B1	0.109	0.128	0.102	0.124	0.058	0.094	0.099	0.077	0.081	0.083	0.079	0.074	0.075	0.088	0.079	0.078	0.031	0.060	0.051	0.035	0.029	0.024
B2	0.106	0.124	0.098	0.120	0.095	0.051	0.096	0.062	0.065	0.067	0.078	0.033	0.047	0.085	0.077	0.077	0.070	0.057	0.062	0.029	0.039	0.026
B3	0.077	0.079	0.081	0.104	0.080	0.064	0.041	0.040	0.056	0.057	0.042	0.025	0.039	0.047	0.055	0.055	0.035	0.045	0.040	0.026	0.016	0.024
B4	0.078	0.111	0.088	0.110	0.073	0.069	0.087	0.029	0.059	0.074	0.033	0.028	0.042	0.065	0.044	0.046	0.039	0.076	0.057	0.028	0.021	0.015
C1	0.082	0.086	0.066	0.099	0.078	0.049	0.053	0.038	0.027	0.042	0.041	0.038	0.038	0.059	0.040	0.040	0.034	0.057	0.038	0.015	0.018	0.012
C2	0.087	0.104	0.081	0.102	0.067	0.065	0.081	0.040	0.043	0.030	0.030	0.038	0.039	0.047	0.042	0.042	0.023	0.046	0.040	0.016	0.017	0.024
C3	0.089	0.087	0.067	0.102	0.079	0.064	0.067	0.039	0.042	0.043	0.029	0.038	0.038	0.046	0.041	0.027	0.022	0.058	0.039	0.024	0.024	0.026
C4	0.076	0.072	0.084	0.037	0.044	0.055	0.044	0.033	0.035	0.035	0.035	0.018	0.030	0.038	0.033	0.019	0.015	0.037	0.032	0.011	0.012	0.023
C5	0.090	0.103	0.094	0.098	0.066	0.051	0.068	0.040	0.029	0.044	0.030	0.039	0.025	0.060	0.041	0.028	0.035	0.046	0.040	0.021	0.030	0.013
C6	0.083	0.081	0.090	0.046	0.076	0.060	0.063	0.038	0.025	0.040	0.039	0.035	0.034	0.028	0.037	0.024	0.031	0.054	0.035	0.021	0.035	0.025
C7	0.087	0.080	0.083	0.100	0.069	0.079	0.083	0.041	0.057	0.044	0.031	0.039	0.039	0.061	0.028	0.029	0.023	0.073	0.040	0.016	0.057	0.013
D1	0.084	0.105	0.082	0.101	0.068	0.052	0.068	0.040	0.043	0.044	0.030	0.039	0.039	0.061	0.041	0.028	0.050	0.046	0.041	0.027	0.030	0.027
D2	0.084	0.101	0.079	0.094	0.064	0.049	0.066	0.039	0.028	0.042	0.028	0.037	0.037	0.045	0.040	0.054	0.021	0.044	0.039	0.015	0.016	0.013
D3	0.087	0.112	0.088	0.111	0.087	0.083	0.087	0.044	0.047	0.035	0.061	0.042	0.042	0.066	0.046	0.060	0.053	0.036	0.044	0.029	0.019	0.015
D4	0.072	0.092	0.072	0.054	0.058	0.042	0.045	0.034	0.022	0.023	0.036	0.033	0.032	0.039	0.021	0.035	0.030	0.038	0.020	0.012	0.013	0.024
E1	0.054	0.068	0.022	0.080	0.022	0.034	0.023	0.028	0.016	0.016	0.016	0.014	0.028	0.019	0.018	0.022	0.034	0.024	0.032	0.010	0.010	0.018
E2	0.086	0.078	0.038	0.085	0.047	0.038	0.044	0.033	0.021	0.033	0.035	0.029	0.030	0.025	0.020	0.032	0.028	0.037	0.020	0.023	0.012	0.021
E3	0.062	0.068	0.023	0.054	0.051	0.037	0.023	0.028	0.019	0.019	0.022	0.016	0.015	0.033	0.018	0.019	0.016	0.031	0.015	0.023	0.010	0.007

	A	B	C	D	E
A	0.186	0.228	0.256	0.165	0.165
B	0.230	0.176	0.260	0.167	0.167
C	0.237	0.222	0.204	0.168	0.168
D	0.237	0.219	0.234	0.136	0.173
E	0.232	0.202	0.247	0.183	0.136

Table AIII. Normalized Td Matrix for the dimension

Table AIV.
Normalized Tc Matrix for the dimension

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	E1	E2	E3
A1	0.165	0.306	0.228	0.301	0.258	0.258	0.299	0.186	0.147	0.140	0.152	0.125	0.128	0.204	0.149	0.238	0.221	0.309	0.232	0.359	0.326	0.315
A2	0.270	0.193	0.252	0.285	0.283	0.268	0.283	0.166	0.142	0.145	0.158	0.116	0.130	0.200	0.156	0.259	0.209	0.280	0.252	0.327	0.431	0.241
A3	0.259	0.303	0.152	0.287	0.266	0.255	0.266	0.213	0.168	0.170	0.166	0.153	0.089	0.154	0.135	0.265	0.131	0.344	0.260	0.347	0.331	0.322
A4	0.260	0.321	0.218	0.202	0.254	0.273	0.288	0.184	0.143	0.146	0.142	0.133	0.136	0.185	0.165	0.250	0.230	0.273	0.247	0.390	0.322	0.288
B1	0.236	0.276	0.221	0.267	0.177	0.286	0.302	0.236	0.145	0.148	0.142	0.133	0.134	0.183	0.164	0.353	0.142	0.272	0.233	0.395	0.331	0.274
B2	0.236	0.277	0.218	0.269	0.313	0.166	0.316	0.205	0.144	0.148	0.172	0.074	0.104	0.227	0.204	0.290	0.261	0.215	0.234	0.308	0.415	0.277
B3	0.227	0.231	0.237	0.305	0.355	0.285	0.182	0.179	0.175	0.177	0.131	0.079	0.120	0.178	0.205	0.312	0.202	0.259	0.227	0.397	0.244	0.359
B4	0.201	0.288	0.226	0.284	0.282	0.269	0.336	0.114	0.173	0.214	0.095	0.081	0.121	0.216	0.148	0.210	0.179	0.349	0.262	0.444	0.326	0.229
C1	0.247	0.257	0.199	0.297	0.356	0.226	0.241	0.176	0.096	0.147	0.145	0.133	0.133	0.241	0.162	0.235	0.203	0.336	0.226	0.328	0.400	0.272
C2	0.233	0.277	0.217	0.273	0.265	0.256	0.321	0.159	0.161	0.113	0.111	0.142	0.143	0.208	0.182	0.279	0.150	0.302	0.268	0.283	0.292	0.425
C3	0.259	0.253	0.193	0.295	0.317	0.256	0.268	0.158	0.152	0.154	0.104	0.136	0.138	0.197	0.172	0.188	0.149	0.395	0.268	0.321	0.321	0.357
C4	0.282	0.268	0.312	0.137	0.249	0.311	0.249	0.191	0.156	0.157	0.157	0.079	0.136	0.197	0.172	0.187	0.143	0.357	0.313	0.238	0.260	0.502
C5	0.233	0.268	0.244	0.256	0.294	0.228	0.301	0.178	0.110	0.164	0.111	0.146	0.093	0.264	0.180	0.188	0.237	0.306	0.270	0.329	0.465	0.206
C6	0.278	0.269	0.301	0.152	0.320	0.254	0.267	0.159	0.106	0.165	0.165	0.146	0.144	0.141	0.182	0.166	0.215	0.374	0.245	0.262	0.433	0.305
C7	0.249	0.229	0.236	0.285	0.253	0.291	0.304	0.151	0.190	0.148	0.103	0.130	0.130	0.226	0.104	0.176	0.141	0.441	0.243	0.185	0.660	0.155
D1	0.225	0.283	0.221	0.271	0.296	0.227	0.299	0.178	0.144	0.148	0.100	0.132	0.132	0.238	0.161	0.172	0.302	0.280	0.246	0.320	0.360	0.320
D2	0.235	0.281	0.221	0.262	0.295	0.226	0.303	0.177	0.109	0.164	0.107	0.146	0.145	0.208	0.182	0.342	0.134	0.278	0.247	0.347	0.364	0.289
D3	0.218	0.282	0.222	0.278	0.287	0.276	0.290	0.146	0.139	0.103	0.179	0.124	0.125	0.225	0.157	0.309	0.274	0.188	0.229	0.458	0.301	0.241
D4	0.248	0.318	0.249	0.185	0.322	0.237	0.250	0.191	0.108	0.112	0.176	0.158	0.156	0.211	0.112	0.284	0.244	0.308	0.164	0.252	0.262	0.486
E1	0.240	0.305	0.099	0.357	0.204	0.321	0.214	0.261	0.123	0.128	0.126	0.108	0.221	0.177	0.165	0.196	0.301	0.213	0.290	0.253	0.258	0.489
E2	0.301	0.272	0.131	0.296	0.292	0.237	0.269	0.202	0.110	0.169	0.181	0.150	0.155	0.145	0.118	0.271	0.241	0.316	0.171	0.415	0.213	0.372
E3	0.300	0.329	0.109	0.262	0.367	0.267	0.164	0.202	0.132	0.135	0.155	0.114	0.103	0.265	0.148	0.232	0.197	0.385	0.187	0.576	0.241	0.183

Table AV. Unweighted matrix(W)

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	E1	E2	E3
A1	0.165	0.270	0.259	0.260	0.236	0.236	0.227	0.201	0.247	0.233	0.259	0.282	0.233	0.278	0.249	0.225	0.235	0.218	0.248	0.240	0.301	0.300
A2	0.306	0.193	0.303	0.321	0.276	0.277	0.231	0.288	0.257	0.277	0.253	0.268	0.268	0.269	0.229	0.283	0.281	0.282	0.318	0.305	0.272	0.329
A3	0.228	0.252	0.152	0.218	0.221	0.218	0.237	0.226	0.199	0.217	0.193	0.312	0.244	0.301	0.236	0.221	0.221	0.222	0.249	0.099	0.131	0.109
A4	0.301	0.285	0.287	0.202	0.267	0.269	0.305	0.284	0.297	0.273	0.295	0.137	0.256	0.152	0.285	0.271	0.262	0.278	0.185	0.357	0.296	0.262
B1	0.258	0.283	0.266	0.254	0.177	0.313	0.355	0.282	0.356	0.265	0.317	0.249	0.294	0.320	0.253	0.296	0.295	0.287	0.322	0.204	0.292	0.367
B2	0.258	0.268	0.255	0.273	0.286	0.166	0.285	0.269	0.226	0.256	0.256	0.311	0.228	0.254	0.291	0.227	0.226	0.276	0.237	0.321	0.237	0.267
B3	0.299	0.283	0.266	0.288	0.302	0.316	0.182	0.336	0.241	0.321	0.268	0.249	0.301	0.267	0.304	0.299	0.303	0.290	0.250	0.214	0.269	0.164
B4	0.186	0.166	0.213	0.184	0.236	0.205	0.179	0.114	0.176	0.159	0.158	0.191	0.178	0.159	0.151	0.178	0.177	0.146	0.191	0.261	0.202	0.202
C1	0.147	0.142	0.168	0.143	0.145	0.144	0.175	0.173	0.096	0.161	0.152	0.156	0.110	0.106	0.190	0.144	0.109	0.139	0.108	0.123	0.110	0.132
C2	0.140	0.145	0.170	0.146	0.148	0.148	0.177	0.214	0.147	0.113	0.154	0.157	0.164	0.165	0.148	0.148	0.164	0.103	0.112	0.128	0.169	0.135
C3	0.152	0.158	0.166	0.142	0.142	0.172	0.131	0.095	0.145	0.111	0.104	0.157	0.111	0.165	0.103	0.100	0.107	0.179	0.176	0.126	0.181	0.155
C4	0.125	0.116	0.153	0.133	0.133	0.074	0.079	0.081	0.133	0.142	0.136	0.079	0.146	0.146	0.130	0.132	0.146	0.124	0.158	0.108	0.150	0.114
C5	0.128	0.130	0.089	0.136	0.134	0.104	0.120	0.121	0.133	0.143	0.138	0.136	0.093	0.144	0.130	0.132	0.145	0.125	0.156	0.221	0.155	0.103
C6	0.204	0.200	0.154	0.185	0.183	0.227	0.178	0.216	0.241	0.208	0.197	0.197	0.264	0.141	0.226	0.238	0.208	0.225	0.211	0.177	0.145	0.265
C7	0.149	0.156	0.135	0.165	0.164	0.204	0.205	0.148	0.162	0.182	0.172	0.172	0.180	0.182	0.104	0.161	0.182	0.157	0.112	0.165	0.118	0.148
D1	0.238	0.259	0.265	0.250	0.353	0.290	0.312	0.210	0.235	0.279	0.188	0.187	0.188	0.166	0.176	0.172	0.342	0.309	0.284	0.196	0.271	0.232
D2	0.221	0.209	0.131	0.230	0.142	0.261	0.202	0.179	0.203	0.150	0.149	0.143	0.237	0.215	0.141	0.302	0.134	0.274	0.244	0.301	0.241	0.197
D3	0.309	0.280	0.344	0.273	0.272	0.215	0.259	0.349	0.336	0.302	0.395	0.357	0.306	0.374	0.441	0.280	0.278	0.188	0.308	0.213	0.316	0.385
D4	0.232	0.252	0.260	0.247	0.233	0.234	0.227	0.262	0.226	0.268	0.268	0.313	0.270	0.245	0.243	0.246	0.247	0.229	0.164	0.290	0.171	0.187
E1	0.359	0.327	0.347	0.390	0.395	0.308	0.397	0.444	0.328	0.283	0.321	0.238	0.329	0.262	0.185	0.320	0.347	0.458	0.252	0.253	0.415	0.576
E2	0.326	0.431	0.331	0.322	0.331	0.415	0.244	0.326	0.400	0.292	0.321	0.260	0.465	0.433	0.660	0.360	0.364	0.301	0.262	0.258	0.213	0.241
E3	0.315	0.241	0.322	0.288	0.274	0.277	0.359	0.229	0.272	0.425	0.357	0.502	0.206	0.305	0.155	0.320	0.289	0.241	0.486	0.489	0.372	0.183

Table AVI.
Weighted matrix (W^*)

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	E1	E2	E3
A1	0.031	0.050	0.048	0.048	0.054	0.054	0.052	0.046	0.059	0.055	0.061	0.067	0.055	0.066	0.059	0.053	0.056	0.052	0.059	0.056	0.070	0.070
A2	0.057	0.036	0.056	0.060	0.063	0.064	0.053	0.066	0.061	0.066	0.060	0.064	0.064	0.064	0.054	0.067	0.067	0.067	0.075	0.071	0.063	0.076
A3	0.042	0.047	0.028	0.040	0.051	0.050	0.055	0.052	0.047	0.052	0.046	0.074	0.058	0.071	0.056	0.052	0.053	0.053	0.059	0.023	0.030	0.025
A4	0.056	0.053	0.053	0.037	0.061	0.062	0.070	0.065	0.071	0.065	0.070	0.033	0.061	0.036	0.068	0.064	0.062	0.066	0.044	0.083	0.069	0.061
B1	0.059	0.065	0.061	0.058	0.031	0.055	0.062	0.050	0.079	0.059	0.070	0.055	0.065	0.071	0.056	0.065	0.065	0.063	0.071	0.041	0.059	0.074
B2	0.059	0.061	0.058	0.062	0.050	0.029	0.050	0.047	0.050	0.057	0.057	0.069	0.051	0.057	0.065	0.050	0.050	0.061	0.052	0.065	0.048	0.054
B3	0.068	0.065	0.061	0.066	0.053	0.056	0.032	0.059	0.054	0.071	0.060	0.055	0.067	0.059	0.068	0.066	0.066	0.064	0.055	0.043	0.054	0.033
B4	0.042	0.038	0.049	0.042	0.041	0.036	0.031	0.020	0.039	0.035	0.035	0.042	0.040	0.035	0.034	0.039	0.039	0.032	0.042	0.053	0.041	0.041
C1	0.038	0.036	0.043	0.037	0.038	0.037	0.046	0.045	0.020	0.033	0.031	0.032	0.022	0.022	0.039	0.034	0.025	0.033	0.025	0.030	0.027	0.033
C2	0.036	0.037	0.043	0.037	0.038	0.038	0.046	0.056	0.030	0.023	0.031	0.032	0.033	0.034	0.030	0.035	0.038	0.024	0.026	0.032	0.042	0.033
C3	0.039	0.041	0.042	0.036	0.037	0.045	0.034	0.025	0.030	0.023	0.021	0.032	0.023	0.034	0.021	0.023	0.025	0.042	0.041	0.031	0.045	0.038
C4	0.032	0.030	0.039	0.034	0.034	0.019	0.020	0.021	0.027	0.029	0.028	0.016	0.030	0.030	0.026	0.031	0.034	0.029	0.037	0.027	0.037	0.028
C5	0.033	0.033	0.023	0.035	0.035	0.027	0.031	0.031	0.027	0.029	0.028	0.028	0.019	0.029	0.027	0.031	0.034	0.029	0.037	0.055	0.038	0.025
C6	0.052	0.051	0.039	0.047	0.048	0.059	0.046	0.056	0.049	0.042	0.040	0.040	0.054	0.029	0.046	0.056	0.049	0.053	0.049	0.044	0.036	0.066
C7	0.038	0.040	0.035	0.042	0.043	0.053	0.053	0.038	0.033	0.037	0.035	0.035	0.037	0.037	0.021	0.038	0.042	0.037	0.026	0.041	0.029	0.037
D1	0.039	0.043	0.044	0.041	0.059	0.048	0.052	0.035	0.039	0.047	0.032	0.032	0.032	0.028	0.030	0.023	0.047	0.042	0.039	0.036	0.050	0.042
D2	0.036	0.034	0.022	0.038	0.024	0.044	0.034	0.030	0.034	0.025	0.025	0.024	0.040	0.036	0.024	0.041	0.018	0.037	0.033	0.055	0.044	0.036
D3	0.051	0.046	0.057	0.045	0.046	0.036	0.043	0.058	0.057	0.051	0.067	0.060	0.052	0.063	0.074	0.038	0.038	0.026	0.042	0.039	0.058	0.071
D4	0.038	0.042	0.043	0.041	0.039	0.039	0.038	0.044	0.038	0.045	0.045	0.053	0.045	0.041	0.041	0.034	0.034	0.031	0.022	0.053	0.031	0.034
E1	0.059	0.054	0.057	0.064	0.066	0.052	0.066	0.074	0.055	0.048	0.054	0.040	0.055	0.044	0.031	0.055	0.060	0.079	0.044	0.034	0.056	0.078
E2	0.054	0.071	0.055	0.053	0.055	0.069	0.041	0.055	0.067	0.049	0.054	0.044	0.078	0.073	0.111	0.062	0.063	0.052	0.045	0.035	0.029	0.033
E3	0.052	0.040	0.053	0.047	0.046	0.046	0.060	0.038	0.046	0.072	0.060	0.085	0.035	0.051	0.026	0.056	0.050	0.042	0.084	0.066	0.051	0.025

Table AVII. Limited matrix

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	E1	E2	E3
A1	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.065	0.066	0.066	0.066	0.065	0.066	0.065	0.066
A2	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
A3	0.056	0.056	0.056	0.056	0.056	0.057	0.057	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
A4	0.071	0.071	0.071	0.071	0.071	0.072	0.072	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
B1	0.072	0.072	0.071	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.071	0.071	0.072	0.071	0.071	0.072	0.072	0.072	0.071	0.072	0.071	0.072
B2	0.065	0.065	0.065	0.065	0.065	0.066	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
B3	0.068	0.068	0.068	0.068	0.068	0.069	0.069	0.068	0.068	0.068	0.068	0.068	0.069	0.068	0.068	0.068	0.069	0.068	0.068	0.068	0.068	0.068
B4	0.046	0.046	0.046	0.046	0.046	0.047	0.047	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
C1	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
C2	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.042	0.043	0.043	0.043	0.043	0.043	0.043	0.043
C3	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
C4	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
C5	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
C6	0.057	0.057	0.057	0.057	0.057	0.058	0.058	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
C7	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
D1	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
D2	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
D3	0.060	0.060	0.059	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.059	0.060	0.060	0.060	0.059	0.060	0.059	0.060
D4	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
E1	0.068	0.068	0.067	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.067	0.068	0.068	0.068	0.067	0.068	0.067	0.068
E2	0.067	0.067	0.066	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.066	0.066	0.067	0.067	0.067	0.066	0.067	0.066	0.067
E3	0.061	0.061	0.060	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.060	0.060	0.061	0.060	0.060	0.061	0.061	0.061	0.060	0.061	0.060	0.061

Note(s): (W^* raised to power 15)