Improving the intellectual capital management approach using the hybrid decision method

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Abstract

Purpose – The purpose of this paper is to propose a novel managerial approach for improving traditional intellectual capital (IC) management, and its other latter improved approaches, by integrating the comprehensive IC model with more reliable decision science methods, including the Delphi technique and the analytic network process. This proposed integration endeavors to resolve the issues of IC management related to intuitive decisions by executives and the lack of information regarding the relationships among the considered elements.

Design/methodology/approach – The proposed method was applied to a real case study of a logistics organization. This application is expected to increase the IC study in this field since logistics is identified as an underdeveloped business in the field of IC management. In this study, the proposed method was used to identify the priorities of IC management of the firm.

Findings – The obtained results showed that the method provides a new managerial approach to IC management by conveying the important weights and priorities of the major and minor IC elements of a logistics business. The obtained outcome also confirmed the results of past studies.

Originality/value – This study provides a systematic and scientific decision framework that improves previous IC management approaches. This proposed method conveys a new management approach by including proper decision science methods with the comprehensive IC framework. This hybrid concept has not been explored by previous IC management approaches.

Keywords Logistics, Intellectual capital management, Multi-criteria decision making (MCDM), Delphi technique, Analytic network process (ANP), IC-index

Paper type Research paper

1. Introduction

Over the past several years, a number of academic research studies have indicated that measuring and managing organizational performance only in terms of financial capital is no longer sufficient for an organization to identify its direction and strategy. Therefore, the management of organizational performance has been significantly transformed from the traditional approach, which mainly focuses only on the values of tangible assets, to a more comprehensive scope, which considers both tangible assets and intangible assets, or intellectual capital (IC). Therefore, over the past few years, various research studies and applications of IC management have been extensively executed, especially in developed countries, since it can offer sustainable competitive advantages to the company (Solitander and Tidström, 2010). Because of the substantial benefits of IC management, there have been several IC models proposed, and most of the concepts (e.g. Bontis, 1996; Stewart, 1997) classify IC elements into three broad categories, including human capital, customer or relational capital and structural capital.

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The management on either all the IC components or even separate IC elements could bring several advantages to organizations, such as enhancing organizational wealth (Kitts *et al.*, 2001), increasing the value of the firm's intangible assets, securing financial performance (Guerrini *et al.*, 2014), etc. Nevertheless, among these numerous benefits, the beneficial impacts among the IC elements differ. Therefore, different resource allocations were suggested in some academic studies (e.g. Kim and Kumar, 2009). Although there were empirical suggestions regarding the resource allocation differences among IC components, the different advantages obtained from each IC element, as well as the diversity and complexity of IC components to solve these mentioned issues, and the identification of the importance and priority of IC management have still only been criticized and addressed in a few research studies (e.g. Lee, 2010; Calabrese *et al.*, 2013). Among these studies, one of the most distinguished problems concerns the performance assessment of diversified IC components since the consideration of performance measurement in terms of the various elements is complicated and difficult due to the multiple-attribute characteristic (Zhao, 2009), especially in regard to their qualitative nature (Lev, 2003).

Therefore, to manage the above-mentioned deficiencies, some research studies tried to integrate multi-criteria decision making (MCDM) methods with IC management models. Nevertheless, most studies still focused on only three rough dimensions of the typical IC concept, and only a few studies applied the MCDM method specifically suited to the IC management characteristics of interrelationships or influences among IC indicators or management strategies. All the same, if this properly suggested MCDM method is adopted with a high number of criteria, it would lead to insufficient resource consumption and high numbers of discordant considerations.

In the past, some studies have proposed approaches to reduce the number of considered elements before applying them to MCDM, addressed the consideration of dependencies among IC components to avoid improper identification of IC management priorities or even applied the comprehensive IC model to more extensively consider IC details and essential elements. Nevertheless, until now, there has been no study that considers these above-mentioned issues altogether. For that reason, the previously proposed approaches could not comprehensively or efficiently identify and appropriately prioritize the IC performance indicators simultaneously.

Therefore, with regard to the aforementioned gap and improvement opportunity, this study aims to propose a new method to address the deficiencies found in the traditional IC management approach, and in its other previously improved forms. Moreover, this improved approach is further applied with a real case study in a logistics business, which is an underdeveloped domain in terms of IC management (Okada, 2004). To provide all the crucial information, the remainder of this paper is divided into five sections, which include the literature review, research framework, the results, discussion and conclusion.

2. Literature review

2.1 Management of IC in the logistics business

Today, IC management is broadly affirmed as the key factor for obtaining a competitive advantage for organizations, since the effective and efficient management of this intangible asset could have several positive impacts on the firm's performance. Therefore, due to the diversity and variety of IC management benefits, this concept has been broadly proposed and developed in several models and frameworks, including: Skandia navigator; IC-index or the thinking and non-thinking IC; technology broker; intangible asset monitor; balance scorecard or BSC, etc. Nevertheless, most of the IC studies roughly divide the IC elements into three broad categories, which include human capital, customer or relational capital and structural capital or organizational capital. Similar to the BSC approach, it roughly divides IC, or the non-financial part, into three major dimensions, including customer, internal process and learning and growth. On the other hand, Roos *et al.* (1997) classify the IC elements into two major categories, including human capital and structural capital (thinking and non-thinking IC), and further finely subdivide them into six minor elements, including competence, attitude, intellectual agility, organization, relationships and renewal and development. The first three subcomponents are part of human capital, and the three latter are structural capital. These comprehensively subdivided components could support the organization to thoroughly manage the IC of the organization.

Not only the development and improvement of IC but also the application of IC management is extensively studied in various industries, such as mobile telecommunication, information and communication technology (ICT), food, education, finance, etc. However, research on IC management in logistics businesses is still limited, so it is widely open to be further studied and improved (Okada, 2004). From the literature reviews, it is evident that most of the IC-related research studies (e.g. Tromba, 2005; Wu and Chou, 2007) focused on each of the IC elements from the three traditional rough dimensions, while there are also a few rare research studies (Wu and Chou, 2007; Han and Ding, 2007) that concentrated on all three traditional components of IC simultaneously. Moreover, prior to this study, there have been no studies on logistics management that applied the comprehensive IC model, or the thinking and non-thinking IC concepts (Roos *et al.*, 1997), extensively with regard to the six IC dimensions.

Because of the above-mentioned reasons, IC management is a crucial matter for any industry, including logistics. In the past, there were some limited academic attempts to study and employ this management approach in logistics businesses; nevertheless, there is still a wide scope and a need to further improve the past approach, which mostly concentrated on the three rough IC elements. Although this improvement could be conducive to comprehensive consideration and management of more diverse IC components, the various elements could also bring a number of managerial objectives and indicators to the organization. Therefore, to efficiently manage them, the identification of priorities is required, and this issue will be examined in the following subsection.

2.2 Improving IC management methods using MCDM methods

As empirically identified in past research studies, management of either one IC element or more could bring various competitive advantages to organizations. Nevertheless, in general, the more components are managed, the more resources are consumed. Therefore, to efficiently use the limited resources of an organization, priorities and beneficial IC indicators should be identified so that the organization can efficiently allocate resources to direct action plans responding to those crucial measures (Kim and Kumar, 2009). However, traditional IC management lacks the ability to examine the importance or priority of candidate measures (Mouritsen *et al.*, 2002); therefore, because of this basic IC management concept deficiency, managers have difficulty in identifying crucial indicators (Han and Han; 2004); this is especially true in the case of complex multiple performance measures, since they may not properly indicate the most advantageous indicators, and, finally, this can result in critical damage to organizational performance (Kim and Kumar, 2009). Therefore, there have recently been several studies aiming to propose the integration of various MCDM methods to solve this sophisticated problem since the decision science method has been identified as the solution for this traditional problem.

In this research, in an effort to concentrate on the exact scope of traditional IC management, studies using MCDM methods with more comprehensive IC methods, including those considering financial assets along with non-financial assets, such as BSC, are excluded from the reviewing processes. Therefore, among the clearly scoped and intensive reviews, which include the adoption of various MCDM methods, the most applied MCDM method for improving IC is the analytic hierarchy process (AHP) or its improved form, which is the fuzzy AHP. The AHP is a decision science approach created to solve the multiple criteria problem involving either quantitative or qualitative data (Saaty, 1980), which directly conforms to the characteristics of IC management. It is a broadly applied MCDM method considering a problem as a hierarchical form with unidirectional hierarchical relationships between levels. The main AHP processes consist of constructing the problem in a hierarchical structure, identifying the relative importance of attributes, comparing sub-attributes (or alternatives) to each attribute and finally calculating priorities and obtaining the overall ranking of attributes and sub-attributes. Some past studies applied the AHP to extract weights and to prioritize typical IC indicators (Han and Han, 2004) and green IC indicators (Liu, 2010), whereas some research studies (e.g. Calabrese *et al.*, 2013, Lee, 2010) used the adapted AHP, known as fuzzy AHP, to similarly consider the relative importance and ranks of IC elements and indicators. The inclusion of the fuzzy logic consideration is aimed to compensate for the vagueness and ambiguity of the decision maker's judgment, even though there was empirical identification that the priority results from the classic AHP and the fuzzy-integrated method are not different (Chatterjee and Mukherjee, 2013; Mosadeghi *et al.*, 2015). In addition, there were further attempts that tried to integrate other decision-making methods into the AHP to overcome the deficiency of the single MCDM method to make better IC management decisions. Kim and Kumar (2009) suggested the adoption of the Delphi technique to first screen the critical IC indicators, reducing them to a manageable number before using them with the AHP to determine the relative importance and priorities. The Delphi approach is a systematic process for obtaining and refining knowledge and opinions from a panel of experts (Paré *et al.*, 2013; Adler and Ziglio, 1996) while maintaining the anonymity of those participants (Dalkey, and Helmer, 1963). It is identified as a powerful strategic management tool that can offer advantages beyond other group-decision making methods (Loo, 2002). Therefore, it has been widely applied for diverse purposes and in varied domains (Okoli, and Pawlowski, 2004; Turoff, 2002; Rowe and Wright, 1999; Mitchell, 1991), such as engineering, health care, education, marketing, information systems, business and economics. Moreover, this well-known method is broadly adopted for filtering several performance measures (Gaudenzi and Antonio, 2006) by the consensus of variety of experts (Levary and Han, 1995) to prevent decision making by an individual.

The advantage of the inclusion of the Delphi method with the other MCDM methods is that it could initially reduce the number of indicators and the decision-making time. Moreover, as the results would be obtained from the opinions of a variety of experts, it could help avoid bias from a single decision maker. In addition to the AHP and extended AHP applications, there are other MCDM methods integrated with IC management approaches, such as the fuzzy technique, the technique of order of preference by similarity to the ideal solution (TOPSIS) (Saeedi *et al.*, 2012), the integration of the entropy method and the TOPSIS method (Dong and Gao, 2012) and the 2-tuple fuzzy linguistic approach (Chen and Tai, 2005).

As presented, several MCDM methods were broadly applied to improve the traditional management of IC. Nevertheless, all of the above-mentioned methods ignore a critical consideration of IC management, which is relationships or influences between IC components, although this crucial attribute is empirically indicated in several of the past research studies (e.g. Wu and Chou, 2007; Han and Ding, 2007). Because of this critical deficiency, some studies then adopted the proper MCDM method known as the analytic network process (ANP). The ANP is a mathematical method that provides a systematic approach to decision making with multiple attributes. It is an improved form of the AHP, and includes the dependency and feedback consideration of the decision problem through pairwise comparisons and the network model (Saaty, 1996). Furthermore, it is an MCDM method that considers both quantitative and qualitative types of data. Regarding the consideration of relationships and both types of data, the ANP has been widely adopted in diverse applications and domains, such as business management, education, engineering, information technology, politics, etc. Similarly, from its advantages, the ANP is a proper method for coping with the issue of data and the relationships between IC elements and measures. Therefore, in the current decade, there have been some limited attempts to improve the IC management approach with the ANP. Wu *et al.* (2012) proposed the hybrid method of the ANP and the decision-making trial and evaluation laboratory, and then applied it to assess the importance of IC in the higher education system. Nedjati and Izbirak (2013) applied the original ANP for prioritizing the IC in a dairy company in Iran. Wudhikarn *et al.* (2013) also proposed the integration of the ANP and the Skandia model to find the critical elements in a new product selection process. These studies consistently insisted on the necessity of ANP application with IC management, since they had unidirectionally identified that this improved the MCDM method and could consider the cause and effect between the IC components, so it could properly prioritize the IC components. Nevertheless, these studies still considered the IC concentrations with regard to only three or four rough dimensions, including human capital, relational or customer capital, structural or process capital and innovation or renewal and development capital.

Either the ANP or the hybrid ANP was integrated with the IC management approach in the past studies. Nevertheless, an ANP involving a real business problem that consists of many criteria could consume much time and resources, and there is also a high possibility that the decision maker would be confronted with a highly complex decision problem and would have to perform inconsistent comparisons, which could lead to an unreliable result. Therefore, because of these issues, an extensive hybrid of the Delphi technique and the ANP was suggested in some academic studies. Nevertheless, this kind of hybrid approach has not been further integrated with the IC management before, even though there exists a somewhat similar study that attempted to combine the Delphi method, the AHP and the IC management approach (Kim and Kumar, 2009).

As already mentioned, there are some studies already using the ANP in IC management; however, for proper decision making with a realistic complex problem, the addition of the Delphi technique with the ANP and the IC management approach is explicitly required. Moreover, a more comprehensive IC model that considers a wide range of intangible assets is needed, as well, since, among the past related studies, there has been no study that concurrently concentrates on the ANP approach and comprehensively considers the six extensive elements of IC by following the thinking and non-thinking IC approaches. Additionally, as presented in both the previous and the current sections, when considering the area or the case of the IC management application, there are limited studies in the logistics domain, and especially so for the prioritization or identification of importance IC components.

Therefore, from the above intensive reviews, it is evident that there is a great opportunity to further improve the earlier IC management approaches by integrating the comprehensive IC model, the thinking and non-thinking IC method, with the proper MCDM methods, the Delphi technique and the ANP; moreover, this proposed method can be applied in the underdeveloped domain of logistics.

3. Research framework

As previously stated in the literature review section, this research aims to develop a new systematic IC management approach by integrating the proper MCDM methods with the extensive IC management model. Therefore, in this approach, three different methods, which include the Delphi technique, the ANP and the thinking and non-thinking IC, are combined as the proposed framework of this research. The overall process of this study is depicted in Figure 1 and is described in the following subsections.

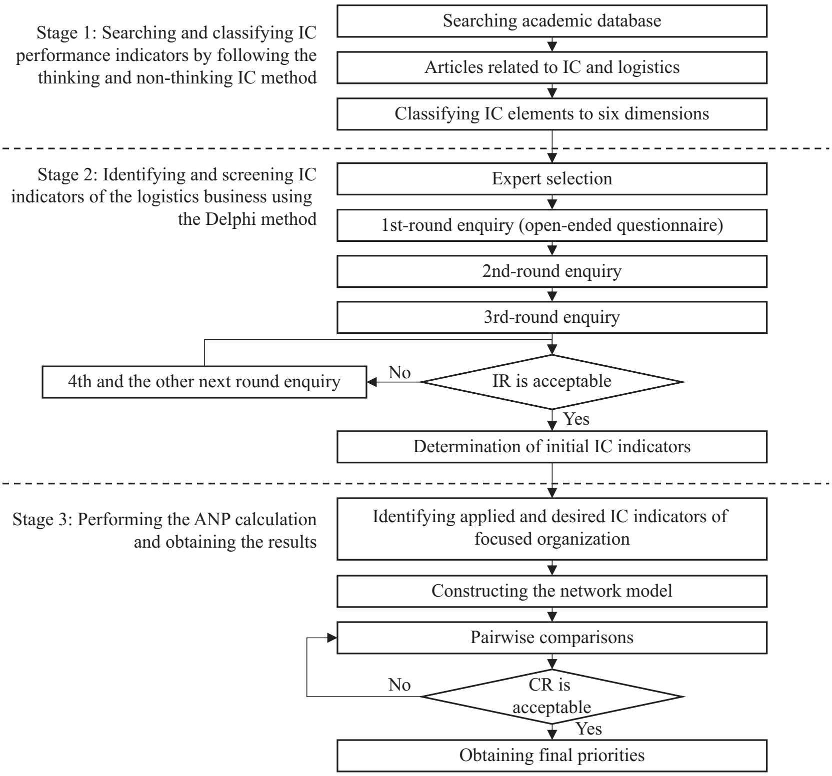

Figure 1.
The proposed research framework

3.1 Stage 1: searching and classifying IC performance indicators by following the thinking and non-thinking IC method

In this step, to initially provide IC indicators in the logistics business to the organization in focus, IC measures from past academic research studies were first extracted and classified into six IC dimensions by following the thinking and non-thinking IC approach.

3.2 Stage 2: identifying and screening IC indicators of the logistics business using the Delphi method

3.2.1 Selection of experts. The first step aimed to identify experts qualified to participate in the inquiry process of the Delphi method. The respondent must be a person who has adequate knowledge or experience related to the research problem. Therefore, in this step, the qualification or specification of experts must be clearly indicated.

3.2.2 First-round enquiry. In this stage, the first questionnaire is designed with open-ended questions. This kind of questioning is applied to avoid answers that are irrelevant to the research objective, while still providing opportunities for the experts to provide detailed information. The constructed questionnaire must be disseminated to all the identified respondents, and then, the obtained answers are used in the next step.

3.2.3 Second-round enquiry. The answers from the earlier enquiry are obtained and then applied to this round of enquiry. In this step, the questionnaire was designed using the five-point Likert scale, and then sent to all the experts. After obtaining all the answered questionnaires, the received results were examined to identify the median and the inter-quartile range (IR). In this study, the selected indicators must have both the median score at the most appropriate level (equal or higher than 4.50), and the IR lower than 1.00 (Rayens and Hahn, 2000).

3.2.4 Third-round enquiry. This stage is carried out based on the results of IR in the previous step. If there are any unacceptable IRs, this round of enquiry is then executed. The questionnaire is duplicated based on the questions from the previous round that had unacceptable IR scores. Each questionnaire is added to the IR score, and the previous answers evaluated by the concerned expert. Therefore, each survey form has the same questions, but different information provided. The questionnaire is sent back to the experts one more time, and in this round if all the obtained results have IR scores at the acceptable level, it is taken as indicative of consistency in the experts' opinions, so the results can be applied to the ANP approach.

3.2.5 Fourth-round enquiry, and the following enquiries. Similar to the previous step, the fourth and the remaining rounds are executed when any IR results of the previous step are higher than that of the acceptable level. The fourth-round and the remaining inquiries are conducted in the same process as was done in the third round. The experts need to reassess the questions that have inconsistent results. These inquiries are conducted repeatedly until all the IR results are acceptable.

3.2.6 Determination of initial IC indicators. The consistent and acceptable results from the previous step are then applied to indicate the initial IC indicators of the logistics business. These identified measures are used as initial information for the ANP approach in the next step.

3.3 Stage 3: performing the ANP calculation and obtaining the results

Because of the word and page limitations of the paper, and the vast details of the ANP method, only the major processes of ANP execution are described. The complete information regarding the ANP method can be found in the globally published book of the inventor (Saaty, 1996).

3.3.1 Identifying applied and desired IC indicators of the organization of focus. Before constructing the network model by following the ANP approach, the indicators obtained from the previous process are applied as the initial data for questioning the expert who is the top executive in the organization of focus. The provided performance measures in the document are selected if the organization applies or desires to adopt these given indicators. If any other required or applied indicator is not included in the questionnaire, the expert can provide that indicator in the available space.

3.3.2 Constructing the network model. After obtaining all the required indicators from the previous step, each performance measure is identified as a node under the relative cluster directly representing the IC dimension. To construct the complete problem model, all measures must be assigned as nodes in one related cluster; thereafter, the relationships between the different indicators and between all of the clusters must be presented as a visualized network map or matrix.

3.3.3 Pairwise comparisons. In this stage, all pairwise relationships, whether at the node or cluster level, are thoroughly compared by following 1-to-9 scales in order to construct the supermatrix, weighted supermatrix and limit supermatrix. Nevertheless, in between the calculations of the supermatrix and weighted supermatrix, consistency checks must be carried out concurrently. When the consistency ratio (CR) is higher than the acceptable level, the pairwise comparisons must be reassessed until acceptable.

3.3.4 Obtaining final priorities. In the calculated limit supermatrix, the values in the columns represent weights or importance values of the considered indicators that are applied for identifying the final priorities and improving the opportunities.

4. Results

The proposed framework discussed in the earlier section was applied to a real case of a global organization, which is a well-known logistics company located in Thailand. This office in focus is unofficially ranked as among the top three logistics businesses in Thailand, and it offers diverse logistics services, including contract logistics, airfreight, ground freight, ocean freight and supply chain solutions. Additionally, the firm also widely serves various business areas, such as automotive, retail, industrial, etc. Since the firm has been recognized as the global leader in the logistics industry, a study on IC management in this organization may present a good model of this undeveloped topic. The details of the processes and the results are presented as follows.

4.1 Searching and classifying IC performance indicators by following the thinking and non-thinking IC method

In this step, the initial key performance indicators (KPIs) of IC management were searched from high-quality academic databases. Three categories of related keywords were identified, as follows: logistics, intellectual capital and success indicators, and the groups consisting of eight related keywords including logistics, supply chain, intellectual capital, IC, intangible assets, key performance indicator, KPI and performance measurement. Therefore, from these indicated terms, there were 24 keyword combinations for searching, which were applied to search for related articles. Next, all the searched articles were screened by concentrating on only the related topics regarding the measurement of IC performance in logistics businesses. A total of 14 academic papers related to reviews and applications of performance measurements in logistics were selected and adopted to determine the initial IC performance indicators. From these academic references, 188 IC indicators were applied as the performance measures in both commercial and academic sectors. However, these measures have not been clearly classified as IC elements by following the thinking and non-thinking IC method. Therefore, based on this method, these initial indicators were classified into six IC sub-elements, as shown in Table I.

As shown in Table I, it is evident from the articles in focus that there is heavy emphasis on performance measurement in the categories of organization and relationships, whereas the numbers of indicators of the remaining elements are still limited. Nevertheless, these obtained and classified indicators were adopted in the next step as examples of IC performance measures in logistics businesses only. The firm in focus could indicate the IC measures by either selecting from the provided lists or providing its own indicators.

4.2 Identifying and screening IC indicators of the logistics business using the Delphi method

The indicators identified from the previous step were applied as additional information to support the questionnaire construction for the Delphi method. In this section, the results from the adoption of the Delphi technique are presented as follows.

Table I. Number of searched IC indicators classified by thinking and non-thinking IC categories

IC category	Number of indicators
Competence	4
Attitude	4
Intellectual agility	2
Organization	138
Relationships	34
Renewal and development	6

4.2.1 Expert selection. To appropriately obtain data from experienced and knowledgeable experts, in this research study, the respondents who participated in the Delphi process were identified as middle- to high-level managers, and the number of experts was set at ten persons by referring to the acceptance levels of the deviation value, time, and resources of this study.

4.2.2 First-round enquiry. As previously mentioned, the indicators from the previous step were adopted as part of the first-round questionnaire, representing an example of IC measures in logistics businesses. The questionnaire was constructed as open-ended questions that aim to determine the current and future adoption of IC measurement in the organization of focus, and the designed forms were disseminated to ten identified experts. After all the respondents returned the questionnaires, the results were clear, and the results showed that the organization initially consisted of 4, 4, 2, 4, 8 and 71 KPIs related to competence, attitude, intellectual agility, renewal and development, relationships and organizations, respectively.

4.2.3 Second-round enquiry. In this stage, the indicators obtained in the previous step were used for developing the second-round questionnaire. This enquiry was the scale assessment format. The same set of experts from the first round selected the level of importance of the indicators to the organization (five-point Likert scale); thereafter, all the answered questionnaires were returned, and the median and inter-quartile values were calculated. However, it was found that the results of IR were higher than 1.00 in 16 indicators. Therefore, because of these inconsistent outputs, the next round of enquiry must be carried out.

4.2.4 Third-round enquiry. The questionnaire in this step was duplicated from the previous round and some information was added to each question, including the IR score and the answer that was provided the previous time. Therefore, each questionnaire to each expert has one dissimilarity point, which is the previous answers corresponding only to that respondent. In this step, the experts were asked to review and reassess only the questions that had an IR score greater than 1.00 in the second round. Similar to the previous step, the obtained questionnaires were collected and recomputed for the IR score and median for all the questions. In this round, the results presented a high level of consistency among the experts (the IR score was lower than 1.00 in all the questions). Therefore, from these calculated results, any indicators that had a score of more than 4.50 were referred to as the most suitable IC indicators for the organization. From then on, those scores and relative measures were adopted for indicating the critical set of IC indicators in the next step.

4.2.5 Determination of initial IC indicators. From the Delphi method results, as presented in the previous steps, 18 indicators were identified as most appropriate for IC performance measurement for the logistics organization of focus. Nevertheless, from among these selected indicators, there were only four of the six sub-elements of IC, which were competence, attitude, relationships and organization. All the selected indicators and their IC categories are presented in Table II.

As presented in Table II, all the obtained IC indicators in the firm of focus are related to both the major elements of IC, namely, human capital and structural capital; however, most of them are concerned with structural capital. Nevertheless, if the sub-element of IC is considered, the concentration of the studied organization involved only four from the six IC dimensions, and most of the indicators were in the area of organization. However, two of the IC elements, namely, intellectual agility and renewal and development, were surprisingly ignored in this organization.

Nevertheless, from the Delphi process, it was evident that all the selected indicators presented equal levels of importance as IC indicators. Therefore, to identify their priority and weighting, the ANP was carried out, as discussed in the next section.

Indicator	IC major element	IC sub-element	Acronym
Percentage of employees completely trained according to the training plan	Human capital	Competence (C)	C1
Annual employee turnover rate	Human capital	Attitude (A)	A1
Willingness and attitude	Human capital	Attitude (A)	A2
Openness and innovation	Human capital	Attitude (A)	A3
Employee satisfaction	Human capital	Attitude (A)	A4
Customer satisfaction	Structural capital	Relationships (R)	R1
Rate of customer complaints	Structural capital	Relationships (R)	R2
Rate of returned goods	Structural capital	Relationships (R)	R3
Market share	Structural capital	Relationships (R)	R4
Unconformity operations	Structural capital	Organization (O)	O1
Accuracy of internal inventory	Structural capital	Organization (O)	O2
Accuracy of external inventory	Structural capital	Organization (O)	O3
Out-of-date deliveries	Structural capital	Organization (O)	O4
Transportation accidents	Structural capital	Organization (O)	O5
Shipping errors	Structural capital	Organization (O)	O6
Inventory losses	Structural capital	Organization (O)	O7
Quantity of goods lost	Structural capital	Organization (O)	O8
Accuracy of invoice	Structural capital	Organization (O)	O9

Table II.
Identified IC indicators from the Delphi method

4.3 Performing the ANP calculation and obtaining the results

4.3.1 Identifying applied and desired IC indicators of the organization of focus. As previously presented, the Delphi method helps the organization to initially identify the IC indicators from the various opinions of the experts. A total of 18 IC indicators of logistics activities, as shown in Table II, were selected from the 188 examples provided. These measures were screened by experts, with the aim of considering the organizational goals. However, the selected indicators could only present similar IC management concentrations. Therefore, to realize the level of concentration of the IC management of this global organization, the ANP calculation was then applied, which is presented in the following steps.

4.3.2 Constructing the network model. All the identified indicators, as presented in Table II, were applied as the nodes in the network model of the ANP, and the IC elements were applied for categorizing them into clusters. In the execution of the ANP, there are several decisions and identifications that must be made by an experienced expert. Therefore, in this research study, the top management of the organization, the general manager (GM), was assigned to respond in this position. The relationships between the nodes as well as the clusters were indicated by this expert through a structured questionnaire, and, from the obtained results, the identified relations at the cluster level or the network model of this case study are depicted in Figure 2. Nevertheless, the node or indicator level cannot be easily demonstrated in network form because of several interrelationships. This case is too complex to illustrate and understand by a figure. Therefore, the relationships of indicators are alternatively depicted in the form of a zero-one matrix presented in Table III.

From Table III, it can be observed that the zero-one matrix represents the influences between the IC indicators identified by the organizational expert. The value of one in a section denotes that the indicator in the vertical axis affects the measure in the horizontal level. For instance, a segment of value between A4 in the vertical axis and A1 in the horizontal axis represents the fact that employee satisfaction (A4) influences the annual employee turnover rate (A1). On the other hand, a segment with a zero value represents non-influence between the two considered indicators.

While the matrix demonstrates the interrelationships between indicators or between nodes, the network model, as presented in Figure 2, represents the relationships between

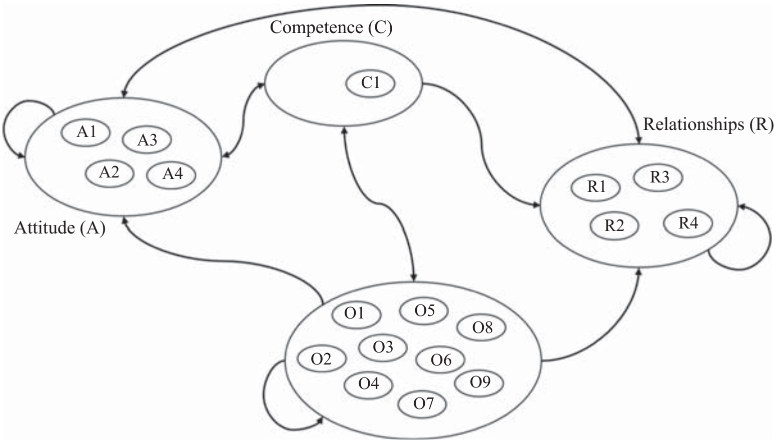

Figure 2. The network model of the case study

Table III. Relationships between IC indicators of the logistics firm of focus

	A				C	O									R			
	A1	A2	A3	A4	C1	O1	O2	O3	O4	O5	O6	O7	O8	O9	R1	R2	R3	R4
A																		
A1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
A3	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
A4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C																		
C1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
O																		
O1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
O3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
O4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
O5	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1
O6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1
O7	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1
O8	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	1
O9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
R																		
R1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1
R2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1
R3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1

clusters or between major IC elements. The line and the arrowhead indicate the influence between the clusters, whereas the arrow heading back to its own sphere demonstrates the influence on itself. For example, the line with the arrowhead starting from the competence cluster and ending in the relationships cluster implies that competence influences relationships, while the arc with the arrow from the attitude cluster pointing back to the cluster indicates influences within the cluster. At the same time, the two-way arrowhead indicates influences of the clusters on each other. For instance, the relationships cluster and the organization cluster can influence each other.

The influence between two clusters denotes that, between groups, there is at least a pair of nodes that relate to each other. In this case study, the GM identified the two-way relationships among entire clusters or IC elements, excepting relations between the competence cluster and the relationships cluster, between the organization cluster and the attitude cluster and between the organization cluster and the relationships cluster. These three exceptions were a unidirectional relation implying that between each pair there is only one cluster influencing the other. For example, in the relationship between the competence cluster and the relationships cluster, the manager believed that the component of competence cluster (C1) could influence some of components under the relationships cluster (R1, R2 and R3), while from his experience, the management distrusted that entire components of the relationships cluster could influence any element under the competence cluster. This implies that the relationships cluster does not influence the competence cluster. Therefore, from this type of relationship, the one-way arrowhead was adopted between these two clusters. Similar to the above-mentioned approach, relationships between indicators from Table III were applied to indicate the overall interrelationships between clusters, as shown in Figure 2.

All the identified relationships at both the node level and the cluster level are applied for making further comparisons, and, thereby, finding the priorities of IC indicators, as presented in the next sections.

4.3.3 Pairwise comparisons. All the identified relationships were adopted to create the comparison questions through the Super Decision software (version 2.80). All of the above-mentioned interrelations between nodes were entered into the software, and the system automatically generated all the comparative questions. The questionnaire is designed to compare the level of influence between two related nodes or clusters. Each pairwise comparison is considered for intensity of importance by following the 1-to-9 scale of the ANP preference (Saaty, 1996).

The software generated 14 and 109 pairwise comparisons for the cluster level and the node level, respectively. These comparative questions were created based on the decisions by the GM of the organization of focus. All the answers were entered into the software to generate all the required results, namely, the supermatrix, weighted supermatrix and limit supermatrix. Nevertheless, for the first-round response, there were some inconsistencies in the experts' answers since the CRs in some questions were greater than 0.10, as shown in Table IV.

According to the depicted results, there were still three inconsistencies in the pairwise comparisons. Therefore, in these groups of questions, the expert was asked to reassess the conflicting comparisons, and after the correction attempt, all the CRs were enhanced to reach the acceptable level or higher than 0.10 for all the questions.

4.3.4 Achieving the final priorities. After all the comparisons were made consistent, the answers were applied to calculate all the required matrices. The computed matrices, including the supermatrix, weighted supermatrix and limit supermatrix, are presented in Tables VI-VIII, respectively. The supermatrix (Table VI) presents the results obtained from the pairwise comparison calculations. Only a segment of the matrix paring two related indicators shows a calculated value. For example, the indicator A1 was influenced by the indicators A2, A3, A4 and C1, as formerly indicated by the expert in Table III. Therefore, the unweighted priorities to A1 were calculated through the pairwise comparisons between all related indicators within a

Table IV.
Pairwise comparisons with CR results higher than 0.10

Pairwise comparisons	Consistency ratio
A1 and other related indicators in the attitude cluster	0.15696
A3 and other related indicators in the attitude cluster	0.22426
O4 and other related indicators in the organization cluster	0.35331

cluster, and this was applied one-by-one until complete. Following this approach, all obtained impacts were assembled to corresponding sections in the supermatrix. Generally, either the identification of relationships or the pairwise comparison between nodes depends totally on a decision of an expert, and these can vary by an organizational situation/characteristic or the decision maker's experience, so the results of these processes can be different in other cases.

The weighted supermatrix (Table VII) presents the weighted priorities that were calculated by the multiplication between the weights of clusters to the respective segments in the unweighted supermatrix. The weights of the clusters or IC elements were computed from the pairwise comparisons similar to the indicator level, unless this considered the cluster level differently. In this study, as shown in Figure 2, all clusters depend on each other and themselves except for the influences of C by R, O by A, and O by R, and the competence cluster does not depend on itself. All related clusters were compared pairwise with each other to calculate the weights of the clusters, while an uninfluenced cluster is identified as having no weight, as shown in Table V. Hence, these obtained priorities were applied for multiplying with corresponding sections of the unweighted supermatrix to convey the weighted supermatrix. For instance, the weight of attitude-to-attitude cluster (0.61592) in Table V was multiplied with values in corresponding segments under the same cluster (attitude-to-attitude cluster) in the unweighted supermatrix, such as the value of segment between A1 in the vertical axis and A2 in the horizontal axis (0.07513). Following this process, the weights were multiplied with corresponding segments for the entire matrix to obtain the weighted supermatrix.

By raising the powers on the weighted supermatrix until the entries converge, the limit supermatrix is obtained, as shown in Table VIII. A value in each row represents the weight of the indicator. From these results, the computed values of the limit supermatrix can be applied to rank the priorities of the IC indicators, as shown in Figure 3.

From this case study, it was evident that 16 of the 18 indicators indicated weights of importance. Additionally, two IC performance measures were excluded from the list at this stage, even though these indicators were previously selected by the GM and other colleagues in the Delphi process. The exclusion of these indicators occurred by the identification of the

	A	C	O	R
A	0.61592	0.12500	0.00000	0.26264
C	0.07967	0.00000	0.20000	0.06644
O	0.16188	0.87500	0.80000	0.15997
R	0.14253	0.00000	0.00000	0.51095

Table V. Cluster weights matrix

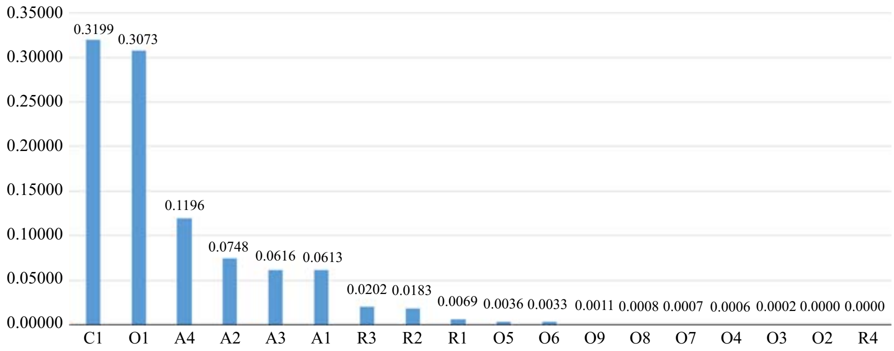

Figure 3. The final priorities of the IC indicators

expert to the indicators' uninfluenced characteristic in the network construction process. Therefore, in the pairwise comparison process, the comparisons with respect to them were ignored. If an attribute does not influence any other attribute, its weight will be zero (Kadoić *et al.*, 2017). This uninfluenced characteristic of the elements/clusters might be found regarding others in the case study (Abdi, 2012) (Tables VI-VIII).

5. Discussion

As revealed by the results presented in the previous section, determination of the importance of IC indicators in the case study of the logistics business demonstrated that there exist dissimilarities in the levels of significance. Moreover, when priorities were considered in more detail, as depicted in Tables IX-XI, there were several interesting points that were either similar or in conflict with other past empirical studies.

From Table IX and Figure 3, it is evident that the uppermost important IC indicator in the case study is the percentage of employees completely trained according to the training plan (C1). However, the second critical IC indicator relates to unconformity operations (O1), which also has important levels similar to the first rank. These two critical parts are relevant to the organization since the summation of their weights is higher than half of all the weights of the IC indicators. Another group of indicators that has lower importance to the other subsidiary levels is the capital of attitude. These performance measures consist of employee satisfaction (A4), willingness and attitude (A2), openness and innovation (A3) and annual employee turnover rate (A1). Finally, the last group that has a weighting importance lower than 0.03 consists of rate of returned goods (R3), rate of customer complaints (R2), customer satisfaction (R1), transportation accidents (O5), shipping errors (O6), accuracy of invoice (O9), quantity of goods lost (O8), inventory losses (O7), out-of-date deliveries (O4) and accuracy of external inventory (O3). Most of the performance measures were assigned weights from the ANP calculation, whereas there were two indicators, namely, market share (R4) and accuracy of internal inventory (O2), that were excluded from this process. This exclusion implies the insignificance or low importance of these indicators to strategic management from the perspective of the decision maker.

Nevertheless, when further analyzed from the perspective of IC, as shown in Tables X and XI, it could be observed that the major element of IC that has the highest importance to the organization of focus was human capital, which had a weight of 0.63715, whereas structural capital was found to have significance only at 0.36285. The finding that the highest weight is that of human capital is consistent with the findings of other past academic research studies, which reported that human capital is the most critical IC element (Bozbura *et al.*, 2007; Lee and Chen, 2009). Furthermore, when considering additional details in terms of the six sub-elements of IC by following the thinking and non-thinking IC concept, as shown in Table XI, similar high-weight elements in the logistics organization in focus could be ranked as competence (0.31988), organization (0.31749) and attitude (0.31727), in that order. On the other hand, the latter element, relationships, was found to be of very low importance to organizational strategy, at 0.04536.

The result of this case study implies that the most critical managerial part of the logistics business is the competence of the employees in an organization. This also conforms to the outcome of other related logistics research studies, which suggested the important of employee education (Kucukaltan *et al.*, 2016) and learning and growth of logisticians (Huang and Jhong, 2012). This is possibly due to the characteristic of logistics, that it is a labor-intensive business, as argued in some logistics-related research studies (Min and Joo, 2006; Kucukaltan *et al.*, 2016). Additionally, this nature of logistics also conforms to the significantly high weight of human capital, which was indicated in this study.

Nevertheless, when taking into consideration other business domains, there are both congruent and inconsistent results. For example, the most critical IC element in research and development intensive firms was identified as human capital (Kim and Kumar, 2009),

Table VI. Unweighted supermatrix

	A				C					O						R		
	A1	A2	A3	A4	C1	O1	O2	O3	O4	O5	O6	O7	O8	O9	R1	R2	R3	R4
A																		
A1	0	0.07513	0.07459	0.14286	1.00000	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0.27895	0	0.60177	0.42857	0	0	0	0	0	0	0	0	0	0	0.20000	1.00000	0	0
A3	0.07193	0.25148	0	0.42857	0	0	0	0	0	0	0	0	0	0	0.80000	0	0	1.00000
A4	0.64912	0.67339	0.32364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C																		
C1	0	0	1.00000	0	0	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0
O																		
O1	0	0	0	1.00000	1.00000	0	0.12196	0.12196	0.1463	1.00000	0.25000	1.00000	1.00000	1.00000	0.06173	0.09639	0.08494	0.08946
O3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02494	0.04077	0	0
O4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14135	0.13451	0	0.19215
O5	0	0	0	0	0	0	0	0	0.32204	0	0.75000	0	0	0	0.12748	0.05814	0.26047	0.05641
O6	0	0	0	0	0	0	0	0	0.53167	0	0	0	0	0	0.16877	0.17094	0.55075	0.24089
O7	0	0	0	0	0	0	0.31962	0.31962	0	0	0	0	0	0	0.0423	0.03967	0.10385	0.04999
O8	0	0	0	0	0	0	0.55842	0.55842	0	0	0	0	0	0	0.16552	0.2019	0	0.37109
O9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2679	0.25768	0	0
R																		
R1	0	0	0	0.12196	0	0	0	0	0	0	0	0	0	0	0	0.25000	0.16667	0.55842
R2	0	0	0	0.31962	0	0	0	0	0	0	0	0	0	0	0.20000	0	0.83333	0.12196
R3	0	0	0	0.55842	0	0	0	0	0	0	0	0	0	0	0.80000	0.75000	0	0.31962

Table VII.
Weighted supermatrix

	A				C	O									R			
	A1	A2	A3	A4	C1	O1	O2	O3	O4	O5	O6	O7	O8	O9	R1	R2	R3	R4
A																		
A1	0	0.07796	0.06646	0.09560	0.12500	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0.27895	0	0.29505	0.28682	0	0	0	0	0	0	0	0	0	0	0.05253	0.26264	0	0
A3	0.07193	0.28720	0	0.28682	0	0	0	0	0	0	0	0	0	0	0.21011	0	0	0.28133
A4	0.64912	0.63484	0.52395	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C																		
C1	0	0	0.11454	0	0	1.00000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.06644	0.06644	0.09010	0
O																		
O1	0	0	0	0.17589	0.87500	0	0.09757	0.09757	0.08682	0.80000	0.20000	0.80000	0.80000	0.80000	0.00988	0.01542	0.01843	0.01533
O3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00399	0.00652	0	0
O4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02261	0.02152	0	0.03293
O5	0	0	0	0	0	0	0	0	0.27564	0	0.60000	0	0	0	0.02039	0.00930	0.05651	0.00967
O6	0	0	0	0	0	0	0	0	0.43754	0	0	0	0	0	0.02700	0.02735	0.11949	0.04128
O7	0	0	0	0	0	0	0.25570	0.25570	0	0	0	0	0	0	0.00677	0.00635	0.02253	0.00857
O8	0	0	0	0	0	0	0.44674	0.44674	0	0	0	0	0	0	0.02648	0.03230	0	0.06359
O9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04286	0.04122	0	0
R																		
R1	0	0	0	0.01889	0	0	0	0	0	0	0	0	0	0	0	0.12774	0.11549	0.30563
R2	0	0	0	0.04950	0	0	0	0	0	0	0	0	0	0	0.10219	0	0.57746	0.06675
R3	0	0	0	0.08648	0	0	0	0	0	0	0	0	0	0	0.40876	0.38321	0	0.17493

Table VIII. Limit supermatrix

	A				C	O									R			
	A1	A2	A3	A4	C1	O1	O2	O3	O4	O5	O6	O7	O8	O9	R1	R2	R3	R4
A																		
A1	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134	0.06134
A2	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475	0.07475
A3	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162	0.06162
A4	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956	0.11956
C																		
C1	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988	0.31988
O																		
O1	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730	0.30730
O3	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
O4	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055
O5	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361	0.00361
O6	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334	0.00334
O7	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065	0.00065
O8	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084
O9	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105	0.00105
R																		
R1	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692	0.00692
R2	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827	0.01827
R3	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017	0.02017

Table IX.
Priorities, weights and details of IC indicators

Rank	Acronym of indicator	Weight
1	C1	0.31988
2	O1	0.30730
3	A4	0.11956
4	A2	0.07475
5	A3	0.06162
6	A1	0.06134
7	R3	0.02017
8	R2	0.01827
9	R1	0.00692
10	O5	0.00361
11	O6	0.00334
12	O9	0.00105
13	O8	0.00084
14	O7	0.00065
15	O4	0.00055
16	O3	0.00015

Table X.
Priorities and weights of Major IC elements

Rank	IC major element	Weight
1	Human capital	0.63715
2	Structural capital	0.36285

Table XI.
Priorities and weightages of IC sub-elements

Rank	IC sub-element	Weight
1	Competence	0.31988
2	Organization	0.31749
3	Attitude	0.31727
4	Relationships	0.04536

whereas studies on universities (Lee, 2010) and the ICT service industry (Calabrese *et al.*, 2013) indicated that relational capital or customer capital was the most important IC element of management. At the same time, a case study on the higher education system in Taiwan claimed that innovation capital was the most crucial IC element (Wu *et al.*, 2012).

From these different results, however, it should be noted that a comparison of outcomes from the above-mentioned studies and this research study brings forth several conflicting aspects, as follows:

- past application of MCDM methods that do not consider the influence of or the interrelationships between IC elements;
- difference in the domains of application; and
- rough classification of IC elements.

Based on the presented results, this research study could help the organization and its executives to improve performance measurement and management to become more reliable and comprehensive in comparison with the traditional IC managerial approach as well as its other previously improved forms. The suggested model replaces the traditional consideration of top management, which mainly relies on experience and intuition, with the reliable decision science methods of the Delphi technique and the ANP. Furthermore, by applying the thinking and non-thinking IC concept, the proposed approach could extend the consideration of IC from the three rough dimensions of IC to six comprehensive perspectives; moreover, the adoption of the ANP could also include consider the IC elements influences on each other, which is surprisingly ignored with the traditional and previously improved IC approaches. Based on this hybrid approach, scholars and commercial practitioners could concentrate on the more critical IC management indicators first; additionally, the obtained outcome can also be further applied for efficiently allocating the limited resources of an organization to manage the critical IC elements, so this can improve the basic deficiencies of organizational management, which involves high wastage of the organization's resources and time.

Additionally, this research study not only provides a novel integration approach, as mentioned previously but also reveals the discovery of IC measurement in an underdeveloped domain, that is, the logistics business. Since, in the past, there have been a very limited number of logistics-related studies that focused on comprehensive IC performance measurement, this study suggested a prioritized list of comprehensive IC indicators that were derived from the application of the proposed method in the case study of a well-known global logistics organization. Hence, these priorities and listed indicators could be applied as an example to other organizations in the logistics industry.

6. Conclusion

This paper proposes a novel hybrid approach that integrates the thinking and non-thinking IC model, the Delphi method and the ANP to comprehensively examine the identification of importance in IC management. This integrated method aims to provide a better management approach by including the decision science methods along with the unscientific managerial side. Moreover, this suggested improvement could also close the critical gaps found in the past studies on IC, namely, the consideration of rough IC elements and the lack of attention to the dependency between IC elements.

For the above-mentioned reasons, this research integrated the three distinctive methods together to provide an appropriate hybrid approach, and then applied it to the case study of a logistics business, which is an underdeveloped area in IC management. In this case, first, a total of 188 IC components of logistics-related activities were initially obtained from the reviewed articles, and then this large number of indicators was reduced to 18 by using the opinions of ten experts through the execution of the Delphi method. Thereafter, these obtained IC components were further prioritized and weighted using the ANP method. In this mathematical process, 16 of the 18 IC components were found to have weights of importance, while two indices had to be excluded from the list. The final output of the ANP provided the priorities of the major IC elements, sub IC elements and IC indicators. In addition, these results could be further interpreted for the concentration of IC management in the logistics organization of focus. The result confirmed the outcome reported by past studies, which also found that the most critical IC element of logistics corresponds to the competence of the employees.

Even though the integration of these decision methods could provide the new management approach with a more reliable and more scientific approach, there are still some limitations with this hybrid method. First, following the Delphi method requirements, the decision making on the criteria selection requires more participants than the traditional approach. The Delphi technique consumes more time because of the process of obtaining participants' opinions while avoiding direct contact. Moreover, this process requires more attention, especially when a group of experts are unable to reach a consensus in few rounds of enquiry. Although the method seems to be impractical for an organization, especially regarding the usage of the traditional questionnaire which is a paper-based approach, currently, the advancement the online technology and web-based applications could better support this enquiry processes to be faster and more practical. Some online tools for the Delphi technique include the Delphi Decision Aid, Mesydel, etc.

Second, this proposed approach requires more calculations from both the Delphi and ANP methods. Particularly, the application of ANP leads to a more complex calculating process and increases comparisons and requires more effort than the previous methods. However, there are currently several decision-making applications available, such as Super Decisions, or Expert Choice, that can help a manager to easily create a complex network and pairwise comparison questions, and quickly calculate the final priorities. The software makes this type of decision more realistic in practical situations. Nevertheless, this method still requires much more time than the traditional management approach, so is still impractical for urgent decision making. Finally, regarding the ANP approach, the identification of IC indicators, relationships, and their relative importance requires an expert who has experience and understands the organization. The results mainly depend on the expert's decisions, and this can vary from decision maker to decision maker and organization to organization. Therefore, there is no an exact result that can be similarly applied to all organizations.

In the future, research, considering a comparative study of other IC integrated with the decision science methods is suggested to determine which method is more proper or feasible for a practical application of a real-world problem. Although this study is developed with the aim to improve all former IC management approaches, this advantage mostly contributes to a conceptual point of view. Therefore, the proposed method still requires more use, especially in the practical applications to determine its deficiencies and future improvement opportunities.

In conclusion, it can be stated that this research study suggests a new hybrid form of the IC management approach that could improve the deficiencies of both the traditional IC method and its other developed models. The adoption of this proposed method could suggest the priority and the concentration of IC management indicators. Nevertheless, because of some limitations of this hybrid method, especially in terms of the practical point of view, an executive should prudently consider the managerial optimum to an organization.

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