

Application of Analytic Network Process (ANP) in Business Environment: A Comprehensive Literature Review

¹A. Jayant, ²V. Paul, ³U. Kumar

^{1,2,3}Dept. of ME, Sant Longowal Institute of Engg. and Tech., Longowal, Sangrur, Punjab, India
(Deemed University Est. by Govt. of India)

Abstract

This paper presents a comprehensive literature review of analytic network process (ANP)'s applications in research and business practices. We conducted an extensive bibliometric analysis covering all available ANP publications in prominent databases. The publications are categorized according to their overall themes, application areas, publication dates, countries of origin and journals. The results indicate that the ANP is predominantly used for selection and evaluation. The majority of publications deal with the ANP as a decision-making tool in the areas of engineering and manufacturing. More specifically, most of the publications can be found in a combination of selection, engineering and evaluation as well as manufacturing and evaluation topic. The theme of this paper is use of ANP in supply chain Management. This paper is an informative summary of the ANP's applications for researchers and practitioners to support their future work by making use of the ANP.

Keywords

Analytical network process; Analytical hierarchy process; Multi-criteria decision making; Supply Chain Management (SCM).

I. Introduction

Recent advances in multi criteria decision making process generated economic and strategic changes in many aspects of modern business, e.g. manufacturing, logistics, finance and marketing.

Is a general theory of relative measurement used to derive composite priority ratio scales from individual ratio scales that represent relative measurements of the influence of elements that interacts within the sub criteria? The ANP is a general form of the AHP [1] [2]. The basic structure is an influence network of clusters and nodes contained within the clusters. Priorities are established in the same way they are in the AHP using pair wise comparisons and judgment. Whereas analytic hierarchical process (AHP) models a decision making frame work that assumes a unidirectional hierarchical relationship among decision levels, ANP allows for more complex inter relationship among decision levels. Many decision problems cannot be built as hierarchical because of dependencies (inner/outer), influences between and within clusters (criteria's, alternatives). ANP is very useful to solve these kinds of problems. ANP provides a general framework to deal with decisions without making assumptions about the independence of higher-level elements from lower level elements and about the independence of the elements within a level. In fact ANP uses a network without the need to specify levels as in a hierarchy [2]. Not only does the importance of the criteria determine the importance of the alternatives as in a hierarchy, but also the importance of the alternatives themselves determines the importance of the criteria. Feedback enables us to factor the future into the present to determine what we have to do to attain a desired future. ANP is a multi-attribute, decision-making approach based on the reasoning, knowledge, and experience of the experts in the field. ANP can act as a valuable aid for decision making involving

both tangible as well as intangible attributes that are associated with the model under study. ANP relies on the process of eliciting managerial inputs, thus allowing for a structured communication among decision makers. Thus, it can act as a qualitative tool for strategic decision-making problems [2]. In the past decades many of the researchers have done a variety of application of ANP to various fields, the ability to rapidly incorporate feedback and a possibility of simple comparison to actual results makes it very powerful method in multi criteria decision making. This study not only provides the evidence that the Analytic network process proved much better in MCDM, but also aids the decision makers and researchers in applying ANP effectively. The Analytical Network Process in the literature is suggested as a solution for large, dynamic and complex problems of multiple criteria decision-making, such as the strategic planning of organizational resources, the evaluation of strategic alternatives and an opportunity of introducing new manufacturing technologies. These problems include numerous, both quantitative and qualitative factors, then many interactive attributes (economic, social, political, cultural, etc.) and complex relations between them. All these problems mostly rely on measurement and relations in the process of multi-criteria decision-making and are based on the estimation of managerial preferences.

II. Analytical Network Process

ANP was firstly introduced by Saaty, which is based on 1-9 scale, in his book named "The Analytic Hierarchy Process (1980)". After that, Thomas L. Saaty developed this issue in his published book named "The Analytic Network Process" (1996). Saaty suggested the usage of AHP to solve the problem of independence on alternatives or criteria and the usage of AHP to solve the problem of dependence among alternatives or criteria. ANP is a generalization of the analytical hierarchical process (AHP). While AHP represents a framework with a unidirectional hierarchical AHP relationship, ANP allows for complex interrelations among decision levels and criteria [1] [2]. The ANP feedback approach replaces hierarchies with networks in which the relations among levels are not easily represented as higher, lower, dominant or subordinate. Given the problems encountered in reality, a dependent and feedback relationship is usually generated among the criteria and such interdependence relations usually become more complex with the change in scope and depth of the decision-making problems. Fig. 1 is presented a close loop framework with dependence relations, which applied in this study ANP feedback approach.

Fig. 1: Dependence Relationship

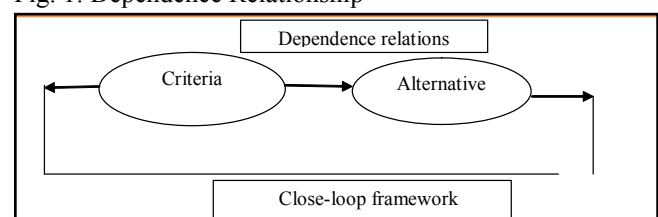


Fig. 1: Close Loop Framework With Dependence Relations

ANP uses a super matrix to deal with the relations of feedback and dependence among the criteria. If no interdependent relationship exists among the criteria, then the pair wise comparison value would be 0. If an interdependence and feedback relationship exists among the criteria, then such values would no longer be 0, and an unweighted super matrix M will be obtained. If the matrix does not conform to the principle of column stochasticity, the decision maker can provide the weights to adjust the matrix into a super matrix that confirms the principle of Stochasticity, producing a weighted super matrix M . The limited weighted super matrix M^* is based on Eq. (3) and allows for gradual convergence of the Interdependence relations to obtain the accurate relative weights among the criteria. The following equations are applied in this study. In testing for the consistency of a judgment matrix, acceptable matrix results have consistency index (C.I) and consistency ratio (C.R.) values less than 0.1 and the C.I. of a judgment matrix can be obtained by

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (1)$$

When $\lambda_{\max} = 0$, complete consistency exists within judgment procedures. When $\lambda_{\max} = n$, the C.R. of C.I. to the mean random consistency index R.I. is expressed as C.R. The equation as follows

$$CR = \frac{CI}{RI} \quad (2)$$

$$M^* = \lim_{K \rightarrow \infty} M^k \quad (3)$$

Where n is the number of elements and RI denotes the average consistency index for numerous random entries of same-order reciprocal matrices. If $CR \leq 0.1$, then the pair wise comparison matrix is consistent; otherwise, a new comparison matrix is solicited until $CR \leq 0.1$. ANP is a mathematical theory that can deal with multiple dependencies systematically. The merits of ANP in group decision-making are as follows: (i) both tangibles and intangibles, individual column values, and shared values can be included in the decision process (ii) the discussion in a group can be focused on objectives rather than on alternatives (iii) the discussion can be structured so that every factor relevant to the decision is considered and (iv) in a structured analysis, the discussion continues until relevant information from each individual member in the group is considered and a consensus is achieved

III. Framework for Literature Review

The research methodology employed for this literature review is the literature survey. The main intention of the literature review was to collect information from several research articles. Some articles published in the recent time on this issue: Kennan Govindan [13], Gopal Agarwal [32] etc. have provided the excellent ground to begin with. The literature search on ANP technique has been carried with the help of Science direct, Springer, E-Journals, Google search engine and SLIET e-library. From this no. of journals are accessed which are published by various publishers. The literature review methodology is shown in fig. 2 and 2(a).

To make review more clearly, scrutiny of collected papers is carried out based on the "Application of ANP in the research". As a result, 57 articles were chosen for the inclusion in this literature review. The area of research is SCM and other field other than SCM. As a summary, the number of articles and their break up is shown below in the Table 2.

Table 1: Number of papers in each classification

Classification area	Number of papers
Total paper collected	57
Basic concept/definition papers in ANP	4
Papers in the area of SCM	34
Others papers	19

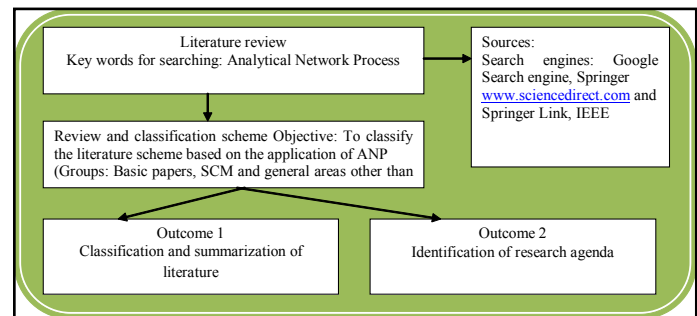


Fig. 2: Literature Review Framework

IV. Classification of the Literature

As the main objective of the literature is to investigate the literature for the use of ANP in supply chain management and other areas, therefore the selected articles are grouped in to three categories focusing on

- (i). ANP concept and definitions basic papers
- (ii). Application of ANP methodology in supply chain management (SCM): The papers in SCM are further sub-classified based on their area of application. Application of ANP in the areas other than SCM. The main classification of literature is shown in the fig. 2 and summary of literature review under the proposed classification scheme are listed in the Tables 3, 4 and 5.
- (iii). Application of ANP methodology in fields other than supply chain management (SCM)

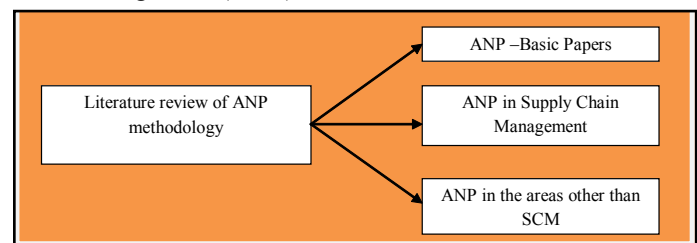


Fig. 2(a): Literature Review Methodology

V. Literature Review

In this section, literature is reviewed on the application and development of ANP

A. The ANP Approach

There are four general steps in ANP based multi criteria decision-making process, including model construction; paired comparisons between each two clusters or nodes; super matrix calculation based on results from paired comparisons; and result analysis for the assessment [1] [2]. As defined by Saaty [1] [2], the ANP is a general theory of relative measurement used to derive composite priority ratio scales from individual ratio scales that represent relative measurements of the influence of elements that interact with respect to control criteria. The ANP is a coupling of two parts: one is a control hierarchy or network of criteria and sub-criteria that control the interactions (interdependencies and feedback); another is a network of influences among the nodes and clusters. Moreover, the control hierarchy is a hierarchy of Criteria and sub-criteria for which priorities are derived in the usual way with

respect to the goal of the system being considered. The criteria are used to compare the components of a system, and the sub-criteria are used to compare the elements of a component. Steps of the ANP analysis for the environmental-conscious construction planning are laid out below from Step A to Step D:

Step A: ANP model construction

This step aims to construct an ANP model for evaluation based on determining the control hierarchies such as benefits, costs, opportunities and risk, as well as the corresponding criteria for comparing the components (clusters) of the system and sub-criteria for comparing the elements of the system, together with a determination of the clusters with their elements for each control criteria or sub criteria. Regarding how to quantitatively select the most appropriate sub-criteria for defined control criteria, two approaches have been developed, including Energy-Time use Index and Environment Impacts Index [40].

Step B: Paired comparisons

This step aims to perform pair wise comparisons among the clusters, as well as pair wise comparisons between nodes, as they are interdependent on each other. On completing the pair wise comparisons, the relative importance weight (denoted as a_{ij}) of interdependence is determined by using a scale of pair wise Judgment, where the relative importance weight is valued from 1 to 9[1].The fundamental scale of pair wise judgment is given below:

In between values can also be taken. The weight of interdependence

is determined by a human decision maker who is a breast with professional experience and knowledge in the application area. In order to facilitate the process of collecting experts' opinions in regard to the importance of sub-criteria as well as control criteria in the questionnaire survey, a pair wise table approach called Pair wiser has been developed so that the number of questions could be dramatically reduced no matter how large the number of sub-criteria could be [40].

Step C: Super matrix calculation

This step aims to form a synthesized super matrix to allow for the resolution of the effects of the interdependences that exists between the elements (nodes and clusters) of the ANP model. In order to obtain useful information for the assessment, the calculation of super matrix is to be conducted following three sub-steps, which transform an initial super matrix to a weighted super matrix, and then to a synthesized super matrix.

Step D: Selection

This step aims to evaluate each alternative so as to select the most appropriate one to support final decision making. The criterion to make this selection is the weights of alternatives that can be taken from the synthesized super matrix. The ANP requires a network structure to represent the problem, as well as pair wise comparison to establish relations within the structure. There are two possible modeling approaches to ANP: the BOCR (Benefits, Costs, Opportunities, and Risks) approach, suggested by Saaty (Saatyand Vargas, 2006)

Table 2: Illustrates Saaty Scale

Saaty Scale	1	3	5	7	9
Criteria	Equal	Moderately dominant	Strongly dominant	Very strongly dominant	Extreme dominant.

Table 3: Number of papers in each classification

Sr. No.	Authors and year of publication	Issues addressed/conclusions
1	Thomas L. Saaty(1996) [1]	Decision Making with Dependence and Feedback: The Analytic Network
1.	Thomas L. Saaty(1997) [2]	The Analytic Network Process
2.	Thomas L. Saaty (1999) [3]	Fundamentals of analytical network process
4	Kazuyuki Sekitan and Iwaro Takahashi (2001) [4]	A Unified Model And Analysis For AHP And ANP

B. ANP Methodology in supply Chain Management

Supply chain management is a set of approaches, the management of upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final market place at less cost to the supply chain as a whole [5]. The objective of literature review in this Classification is to investigate the application of ANP in SCM. Table 4 and 4(a) presents the ANP studies on the supply Chain management A few studies are based on the optimization of the supply chain but recent studies are focused on building of decision support systems e.g. supplier selection for a project/Industry ,Green supply chain Management strategies.

C. ANP Applications in the Areas Other Than SCM

Table. 5 and 5(a) presents the ANP studies on the supply Chain management A few studies are based on the optimization of the

supply chain but recent studies are focused on building of decision support systems e.g. supplier selection for a project/Industry ,Green supply chain Management strategies.

VI. Conclusion

In this paper, an attempt has been made to review the literature for deployment of ANP in SCM and area other than SCM. This literature survey serves as a good base for identifying the agenda and provides a clear guidance to researchers in developing, defining and identifying their research agenda for applying ANP methodology in the research. Besides, from the foregoing discussion on the literature review, it can be concluded that ANP is used by various researchers for Multi- criteria Decision making in the variables of supply chain management for improving the performance of supply chains. ANP is used in supplier selection, reverse logistics and Green Supply Chain Management. The

ANP is also used in other areas by the researchers to increase the performance of that field.

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Table 4: Details of publication

Sr. No.	Authors and year of publication	Issues addressed/conclusions
1.	Tomokatsu Nakagawa and Kazuyuki Sekitani (2004)[6]	Addressed a new use of ANP on SCM strategic decision analysis such as a supplier selection and improvement of supply chain performance.
2.	Chiau-Ching Chen et al.[38]	Designate the appropriate green supply chain management (GSCM) strategies for electronic industries to control their business functions and activities effectively.
3.	Hernández Toledo Cecilia et al. (2012) [7]	Identified how different Reverse Logistics programs can affect corporate performance indicators.
4.	Gulsen Akman and Hamit Piskin (2013)[8]	Model for evaluating green performance of suppliers is proposed, and a hybrid multi-criteria decision making model is developed in order to evaluate green performance of the suppliers. Green performance of 18 suppliers of an automobile company was evaluated by this model. These 18 suppliers manufacture chassis and its components.
5.	Palanisamy Parthiban (2011)	Evaluated A Model for Supplier Selection.
6.	Yang YH [10]	Selection of logistics service providers for air cargo.
7.	Sanjay Jharkhariaa and Ravi Shankar (2007)[11]	Presented a comprehensive methodology for the selection of a logistic service provider. The proposed methodology consists of two parts: (i) preliminary screening of the available providers, and (ii) analytic network process (ANP) based final selection.
8.	Kai-Ying Chen and Wan-Ting Wu (2011) [12]	Decision-making method was developed to help the electronic companies that need to evaluate and select the logistics service provider type. Results of this research showed the best logistics service type for electronic companies is the international logistics service provider type.
9.	Govindan Kannan (2013) [13]	Presented a multistep process to select a third-party reverse logistic provider (3PRLP).
10.	Safar Fazli and Azam Masoumi (2012)[14]	Assessed the vulnerability of supply chain. The results showed that in this industry, supply (supplier) side is the main driver of supply chain vulnerability. Also supplier's dependence was identified as the main supply chain vulnerability drivers, this result found by investigating of 18 vulnerability drivers in areas of supply, demand and structure of supply chain.
11.	K. Shahroudi and H. Rouydel (2012)[15]	Presented an integrated model and a supporting approach for effective supplier selection decisions and determined optimum order allocation in Iranian auto industry.
12.	Sarkis and Talluri (2002)[16]	Applied ANP to evaluate and select the best supplier with respect to organizational factors and strategic performance metrics, which consist of seven evaluating criteria. The impact of these factors among themselves was considered.
13.	Bayazit (2006)[17]	Proposed an ANP model to tackle the supplier selection problem. There were ten evaluating criteria in the model, which were classified into supplier's performance and capability clusters. To formulate interrelationships among all criteria, each of them was considered as a controlling factor for a pair wise comparison matrix.
14.	Gencer and Gürpınar (2007)[18]	Implemented an ANP model in an electronic company to evaluate and select the most appropriate supplier with respect to various supplier evaluating criteria, which were classified into three clusters. The interrelationships among the criteria were considered in the selection process.
15.	Vinodh (2010)[19]	Formulated conceptual model for supplier selection encompassing various criteria and sub-criteria. In this article, fuzzy analytic network process (fuzzy ANP) approach was used for the supplier selection process and the model was implemented in an Indian electronics switches manufacturing company.
16.	LI Chun Hao (2008)[20]	Selected appropriate suppliers by means of ANP-BOCR and applied the technique to a real time case study to select steel providers.
17.	CevriyeGencer (2007)[21]	Developed an ANP model for evaluation of the relations between supplier selection criteria and the proposed model was implemented in an electronic company.

18.	Hsu and Hu (2007, 2009)[22][23]	Applied ANP for green supplier selection to further incorporate interdependencies among decision structure components. Their argument was that ANP captures both quantitative and qualitative criteria, reflecting a more realistic result offering managerial insights while selecting suppliers systematically.
19	Buyukozkan and Cifci (2010, 2011) [24][25]	Developed a novel approach based on a fuzzy ANP model within a multi-person decision making scheme under incomplete preference relationships. This method advantages allows for sufficient evaluation by using the provided preference information and maintaining the evaluation consistency.
20.	R.J. Kuo (2010)[26]	Developed a green supplier selection model which integrated artificial neural network (ANN) and two multi-attribute decision analysis (MADA) methods: data envelopment analysis (DEA) and analytic network process (ANP). It also discovered that ANN – MADA had better power of discrimination and noise-insensitivity in evaluating green supplier's performances. The final green supplier selection had six dimensions including quality, cost, delivery, service, environment and corporate social responsibility.

Table 4(a) Details of Publications

21.	Lin (2012)[27]	Modeled a green purchasing system by applying the analytic network process (ANP) and linear programming (LP) methods. The ANP provided the solution for green supplier selection. It consisted of criteria like energy saving, pollution reduction, social responsibility etc.
22.	Sarkis (2003) [28]	Discussed components and elements of green supply chain management. The decision framework was modeled and solved as an analytical network process (ANP).
23.	Agarwal (2010)[29]	Presented a methodology to evaluate suppliers using portfolio analysis based on the analytic network process (ANP) and environmental factors. The study introduced green criteria into the framework of supplier selection criteria. The study consisted of four main criteria clusters or dimensions as operational life, environmental friendly, overall performance, and process management. There were 21 sub criteria under the main four dimensions.
24	Kuo and Lin (2011)[30]	Proposed a method which integrates ANP and DEA for green supplier valuation. DEA and ANP consider the interdependency between the criteria. It expands on DEA by allowing users to restrict the weights using their own criteria weight preferences. This approach also allows for more flexibility on the number of decision making units (DMUs) used
25.	Gopal Agarwal and Lokesh Vijayvargy (2011)[31]	Presented a methodology to evaluate suppliers using portfolio analysis based on the analytical network process (ANP) and environmental factors.
26.	Ming-Lang Tseng and Yong Geng(2011) [32]	Proposed set of criteria for printed circuit board (PCB) manufacturing firm and used a hybrid fuzzy multi-criteria decision-making (MCDM) technique to address the dependence relations of criteria in hierarchical structure with the aid of the interpretive structural modeling (ISM) and analytical network process (ANP) in linguistic preferences. Fuzzy set theory is used to interpret the linguistic preference in accordance with the subjective evaluation.
27.	Felice De F.(2012)[33]	Proposed a systematic approach integrating index methods for Environmental Performance Evaluation (EPE) and Life Cycle Assessment (LCA) with a multi-criteria model based on the Analytic Network Process (ANP) and BOCR Analysis (Benefits, Opportunities, Costs and Risks) for a firm of TV & AUDIO VIDEO production supply chain that can be used to evaluate its own supply chain environmental performances. The key aspect of the model was the consideration of environmental directives such as the Waste Electrical and Electronic Equipment and the Restriction of the use of certain Hazardous Substances to evaluate and prioritize which green initiatives with respect to environmental performance.

28	Agarwal (2006)[34]	Explored the relationship between lead-time, cost, quality, and service level and the leanness and agility of a case supply chain in fast moving consumer goods business. The paper justified the framework, which analyzed the effect of market winning criteria and market qualifying criteria on the three types of supply chains: lean, agile and leagile.
29	Petrillo A.(2011) [35]	Proposed a systematic approach that a firm may use to evaluate its own supply chain environmental performances. The approach integrates index methods for Environmental Performance Evaluation (EPE) and Life Cycle Assessment (LCA) with a multi-criteria model based on the Analytic Network Process (ANP) and BOCR Analysis (Benefits, Opportunities, Costs and Risks).
30.	Ali A. YahyaTabar and Hadi Charkhgard (2012) [36]	Proposed an integrated method using Analytic Network Process (ANP) and Fuzzy-Technique for Order Preference by Similarity to the Ideal Solution (FTOPSIS) .The ANP was used to calculate the weights of each criteria of the model and fuzzy TOPSIS was used to select the best supplier.
31.	Yu-Ting Lee(2008)[37]	Proposed a model method combining multiple intelligences theory with ANP approach to help companies that need to select competent supply chain managers. Additionally, an empirical study was presented to illustrate the application of the proposed method.
32.	Houshang Taghizadeh and Mehdi Ershadis (2013)[38]	Developed an integrated analytical approach, combining quality function deployment (QFD) and analytic network process (ANP) approach, to evaluate the performance of suppliers. The effectiveness of the proposed approach is demonstrated by applying it to water industrial.

Table 5: Details of Publications

S. No.	Authors and year of publication	Issues addressed/conclusions
1.	Shaho Karami et al.(2013)[41]	Strengths and weaknesses due to internal factors and opportunities and threats caused by external factors were identified. Based on the findings, relevant strategies and Analytic Network Process was applied as an effective multi-criteria decision-making method to prioritize the strategies for the sustainable development of a village.
2.	Thomas L. Saaty (2008)[42]	Summarized a mathematical theory of measurement in decision making and applied it to real-life examples of complex decisions.
3	Neira Erika (2009)[43]	Developed a model based on ANP to estimate the market share for the diapers sales. The results were validated by comparing the ANP model's estimations with market share's ones done by Nielsen. These results showed that there is no significant difference between the ANP results and the Nielsen statistics.
4	G. Thangamani (2012)[44]	Described a decision making methodology using Analytical Network Process (ANP) for technology selection for Product Innovation for promising next generation clothes dryer technologies.
5.	Hsu (2012)[45]	Selection of potential sites for CO ₂ geological storage as basis for further exploring geological features and simulation of transport characteristics.
6.	Ozden Bayazit and Birsen Karpak (2007) [46]	Developed an analytic network process (ANP)-based framework to identify the level of impact of different factors on total quality management (TQM) implementation and to assess the readiness of the Turkish manufacturing industry to adopt TQM practices.
7	Ebru YAZGAN and A.Korkut ÜSTÜN (2011)[47]	Determined the weights of selection criteria for civil pilots. Criteria were classified into three main Criteria and 15 sub-criteria. These criteria's were evaluated using ANP.
8.	Predrag Mimovic(2012)[48]	Described the application of Analytic Network Process (ANP) in the modeling and analysis of various factors and the impact on the forecasting of the sales of Fiat 500L.

9	Chen (2008)[49]	Establish a mechanism for partner selection via adapting relative weights of criteria according to the priority of motivations for establishing strategic alliance. They found out that the objectives of forging alliances vary depending on specific motivations.
10	Asadallah Najafi (2013)[50]	Approach for selecting strategies influencing the productivity of knowledge women workers. A case study was presented where this model is measured by the Alupan, Mobarakeh Steel and Iran cell companies.

Table 5 (a) Details of publications

11	Eddie W. L. Cheng and Heng Li(2004)[51]	Proposed and implemented ANP model for Contractor selection.
12	Begičević (2007)[52]	Validated the theoretical model for strategic planning of e-learning implementation by means of factor analysis, presented the structure of AHP and ANP models for decision making about e-learning implementation. Compared developed AHP and ANP models for e-learning.
13.	Patrizia L. Lombardi (2007)[53]	Applied framework of concept of urban sustainability, guiding the selection of appropriate criteria for evaluating alternatives solutions to an Italian urban (re)development problem by using the Analytic Network Process (ANP).
14	Kuang-Husn Shih et al.(2013)[54]	Applied DEMATEL-ANP to solve the complex relations between criteria dimensions, in order to further select the ideal system implementation model. The results showed that, companies with limited resources prefer to choose an out-sourcing implementation model in order to save labor, cost, And time, while ensuring the stability of the system after implementation.
15	Thomas L. Saaty(2009)[55]	Application of ANP in entertainment business, the expansion of Disney amusing parks by establishing a new theme park in greater China.
16.	Laura M. Meade and Adrien Presley(2002) [56]	Discussed the requirements of the R&D project Selection problem, which requires the allocation of resources to a set of competing and often disparate project proposals and evaluated the model using ANP.
17.	Ya-Fen Lee(2012)[57]	Presented an approach for selection of migrating to a new location under the global warming.
18	Yijun Zhang(2014)[58]	ANP model was set up for checking organic chemistry teacher's bilingual teaching competency, and the Super Decisions software is used to compute the comprehensive weight of the 13 impact factors.
19	Hung-da Wan (2014)[59]	Used ANP to prioritize a list of lean tools that need to be implemented urgently considering the current Status of a manufacturing firm. A hypothetical case study was used to demonstrate that the proposed decision making approach was capable in selecting lean tools that are applicable, suitable, and urgently needed according to user's inputs.