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Using Analytical Network Process for Ranking Educational Factors Influencing on Knowledge Worker Productivity

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Abstract: It is commonly recognized that knowledge is the only source of core competence in the knowledge based companies, but the productivity rate of knowledge workers is always Low. Based on knowledge workers' characteristics, in this paper, we seek to identify educational factors influencing on the Productivity of Knowledge Workers, then educational strategies present for improvement of Knowledge Workers Productivity. Finally, the best strategy ranks using Analytical Network Process (ANP) approach. It is hoped that this paper will help managers to implement different corresponding measures. A case study is presented where this model measures and validates at the Alupan & Mobarakeh Steel and irancell companies.

Key words: Knowledge management · Analytical network process · Education · Knowledge workers · Alupan · Mobarakeh steel · Irancell

INTRODUCTION

Activities done in the fields of knowledge management are in the early stages of its growth [1]. One of the ways that knowledge management can be successful is that it brings first make sure the organization technically have the ability to run. Human resource management is therefore important in any organization. Studies done by the researchers in 2009 identified more than 90 percent lead organizations implemented have adhered to this requirement, secondly factors affecting successful knowledge management should be identified. Basic research has proven that human resources are the most important factor for knoweledge workers improvement. Nowadays, human resources position in organization not only revised their strategic role in the successful management has been gradually accepted, but have concluded that human factors over technical issues led to successful organizations [2]. Despite these findings, only a small ratio of the number of empirical research has been done so far [1]. In the past, organization success has been analyzed based on three main factors, including cost, time and performance [3]. One of the fundamental problems of the past approach is lack of attention to other aspects of the knowledge workers [4, 5]. The study tried to examine the most important dimensions of knowledge workers productivity improvement. Human resource management process contains the necessary coordination of human resources in the organization. Knowledge workers involved in intellectual will spend more resources. If management is not suitable for the organization affects output quality. The other hand, the increasing interest around knowledge worker and has caused a significant body of empirical research to emerge, examining the impact of different knowledge workers factors on Knowledge Worker Productivity. However, minimum attention has been given to the conception or understanding of the specific strategies through which knowledge workers factors such as educational factors influence knowledge workers productivity.

Improving the productivity of knowledge workers is one of the most important challenges for companies that face the transition from the industrial economy to an economy based on information and knowledge [6, 7]. Knowledge workers are obviously non-manual workers and are usually employed by organizational managers to carry out innovative activities. Knowledge Worker is a member of the project organization who uses knowledge to be a more productive worker [8, 9]. A knowledge worker is anyone who works for a living at the tasks of developing or using knowledge [10].

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Table 1: Knowledge management process

Process	*Factors*
Identification of knowledge	KWP_{id}
Creation of knowledge	KWP_{cr}
Capturing of knowledge	KWP_{ca}
Application of knowledge	KWP_{ap}
Sharing of knowledge	KWP_{sh}
Saving & Storage of knowledge	KWP_{ss}

Organizational managers that aims to continually improvement in organization, they should be consider the educational factors as a part of the management process and as a strategic element in organizations. The educational factors of knowledge workers are divided to three sections (will, can, May) in organizations. A scientific method is needed to classification of educational factors in organizations. We use the Analytical Network Process (ANP), which measures strategic factors' inter-dependence as effectively as AHP (Analytical Hierarchy Process) measures these factors' independence. AHP cannot measure the factors' existing dependence since AHP considers the factors as completely independent; and it cannot effectively measure environmental and central elements [11,12].

This Study Is Divided into Eight Sections: Section one deals with knowledge workers and educational factors; Section 2 presents Research methodology and the proposed ANP algorithm for analysing the effective educational factors of knowledge workers on Knowledge Worker Productivity; Section 3 presents the case study of the Alupan & Mobarakeh Steel and irancell companies; the remaining sections analyse the research findings and present the research results and questions for future research.

Knowledge Workers and Educatinal Factors: Knowledge is a combination of experience, values and new information. Knowledge management, discovery, creation and development, sharing, maintenance, evaluation and suitable utilization are achieved through effective utilization of human resources, information technology and communications by knowledge workers [13]. A Knowledge worker creates knowledge, knows how to tap and share it across an organisation and then reuses this knowledge whenever necessary – and he/she usually works against a deadline like yesterday [14, 15].

Relationship Between Knowledge Management and Educational Factors: Knowledge Worker Productivity factors are achieved in six steps of knowledge management in Table 1 [16].

According to Knowledge management process, for optimal management of knowledge workers that must identify factors in six section of process.

Educational Factors Classification: As mentioned, educational factors are extracted and classified in three categories (individual, job, organization). In this section, we will extract the sub-factors. Educational factors are defined in Figure 1.

According to the above classification, we should design a method based on ANP, which calculates the factor weights and extracts a strategy for improving knowledge worker productivity management.

Research Methodology: It was decided to adopt a case study approach for this paper as there is little existing research on measurement and identification of educational factors. It has been based on the descriptive Research. This descriptive type research has been carried out using the questionnaire as the research tool for gathering the required data. Data gathering involved both reference material and a questionnaire survey. Sampling was simple random sampling and the data gathering instrument was the questionnaire. The author had already undertaken research in this field which had stimulated the measurement tools and the theoretical framework used to analyze this case study, based on ANP Method.

In November 2007 a request for interviews and questionnaires was sent to a number of the managers (240 persons, 40% Male and 60% Female, 65% over 15 year's experience) and staff (210 persons, 35% Male and 65% Female, 65% over 20 year's experience) in the Alupan & Mobarakeh Steel and irancell company's projects. Prior to the interview and fill the questionnaire, the author explained the purpose of the research and made it clear that this information would be in the public domain, so any confidentiality concerns could be noted. The interview and questionnaire, from December 2007 to April 2009, lasted five hours per week. The interview and questionnaire was semi-structured in nature, starting off with general questions on the company background and Knowledge Workers to put the respondent at ease. Detailed questions based on the educational factors and related frameworks were then used to gather information, with other questions included so as not to limit the information collected. Care was taken not to produce

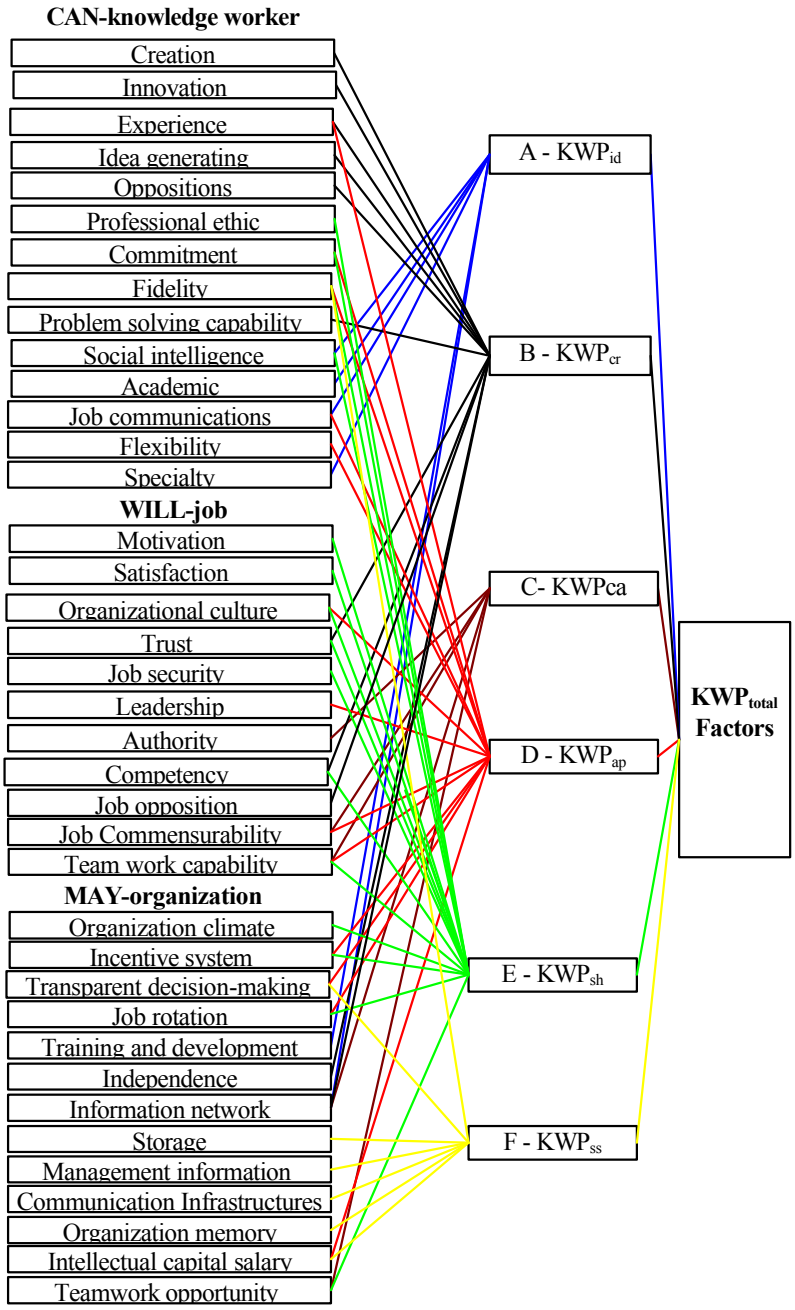

Fig. 1: Educational factors influencing on the Knowledge Worker Productivity

expected answers and flexibility was allowed in the process which enabled an effective two-way dialogue to emerge. To ensure internal validity the interview and questionnaire was transcribed and sent to and staff in the Alupan & Mobarakeh Steel and irancell companies for confirmation of accuracy and to check that no commercially sensitive information had been included. Generalizability of the research has been based on Partial generalizations, it is possible to similar populations and the knowledge generated by qualitative research is significant in its own right. Problems related to sampling and generalizations may have little relevance to the goals of the study and the reality of the situation. In this situation, a small sample size has been more useful in examining a situation in Company from various perspectives. The goal of a study has been be to focuses

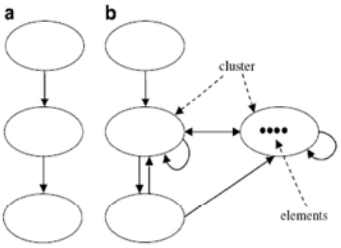

Fig. 2: Structural difference between hierarchy (a) and network (b)

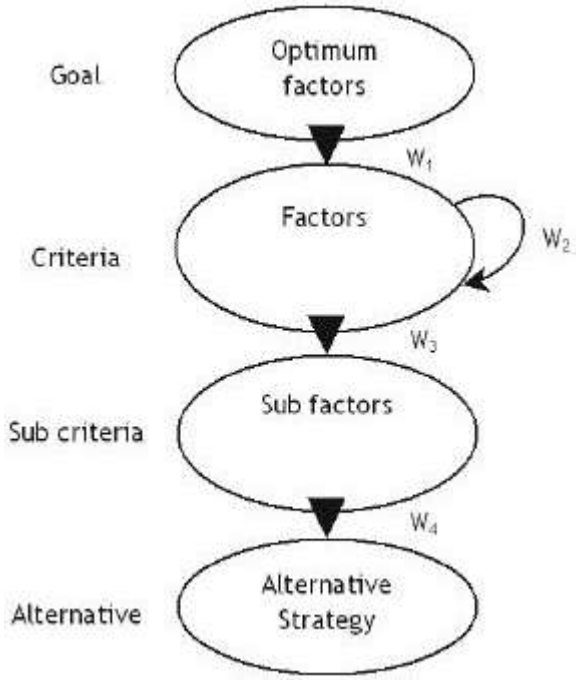

Fig. 3: Network model structure

on a selected contemporary phenomenon such as Knowledge Workers factors or measurement addiction where in-depth descriptions would be an essential component of the process. According to research methodology, it presents ANP method for analyzing of factors.

Network Analysis Process: The ANP is a generalization of the Like AHP, while the AHP represents a framework with a unidirectional hierarchical AHP relationship, the ANP allows for complex interrelationships among decision levels and attributes. The ANP feedback approach replaces hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominant or subordinate, direct or indirect [17]. Figure 2 presents Structural difference between hierarchy (a) and network (b).

ANP is considered comprehensive and explanatory for multipurpose decision-making discussions and also for solving complex decision-making issues. Studies by Yüksel and Dag¡deviren used ANP to select information system projects that are internally dependent. These studies saw no requirement for doing an ideal zero and one programming. Karsak, Partovi and Corredoira have used ANP in quality activity development [18]. A system with reflective state can be explained by a network. The structural difference between the hierarchy and the network is depicted in Figure 3. The existent element in each cluster can affect all or some of the other cluster elements. A network may contain main clusters, middle clusters and final clusters. Arrows show the relationships in the network and their direction shows the dependence. The dependence among clusters can be named external dependence and the internal dependence among elements of a cluster can be called circle dependence [19, 11].

ANP Algorithm:

Step 1: Problem structure and modelling
Step 2: Pair wise comparison matrix
Step 3: Super matrix
Step 4: Selection of best alternative

Using the Anp Approach in Selecting Knowledge Strategies Influencing on the Knowledge Worker Productivity: The network model used in this research is presented in Figure 3.

$$W=\begin{array}{l}\text{Goal}\\ \text{Factors}\\ \text{Sub Factors}\\ \text{Alternative}\end{array}\begin{bmatrix}0 & 0 & 0 & 0\\ w_{21} & 0 & 0 & 0\\ 0 & W_{32} & 0 & 0\\ 0 & 0 & W_{43} & 0\end{bmatrix},$$

Where W21 is the vector of aim or goal effect on criterion, W32 is the matrix of criterion effect on sub-criterion, W43 is the matrix of sub-criterion effect on options and I is the single matrix. Figure 4 shows the factors' model network. The hierarchy in the network is depicted by the clusters' internal dependence without reflection.

The main steps of the method are as follows. The first step is locating the element factors, sub-factors and options. Then, according to the internal dependence relationship among the element factors, one determines the internal dependence, element factors' weights and strategic options' priority vectors, respectively, based on the sub-factors. The following matrix depicts a general sub-matrix for the element model.

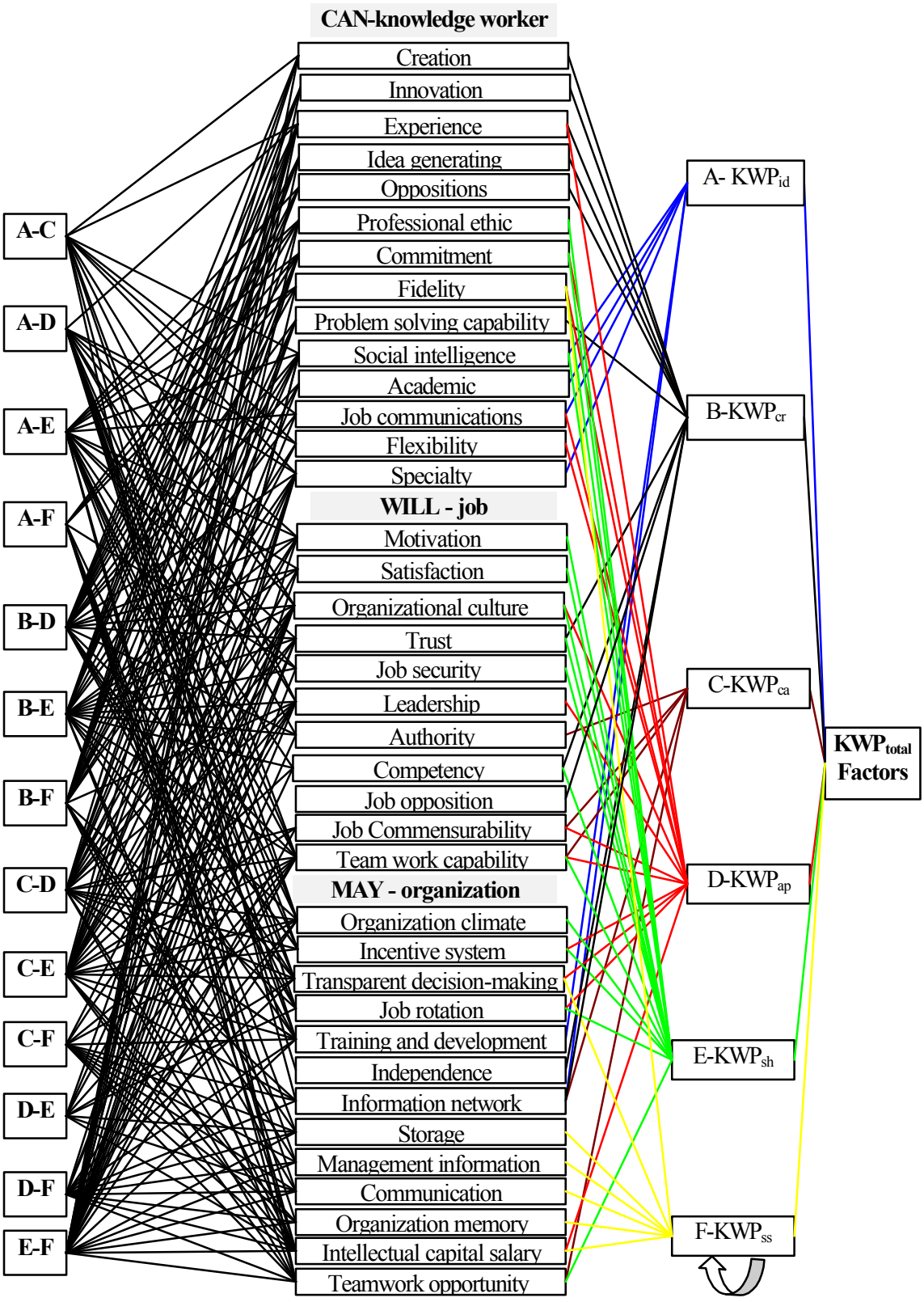

Fig. 4: Educational strategies influencing on knowledge workers productivity

$$W=\begin{array}{l}\text{Goal}\\ \text{Factors}\\ \text{Sub Factors}\\ \text{Alternative}\end{array}\begin{bmatrix}0 & 0 & 0 & 0\\ w_1 & W_2 & 0 & 0\\ 0 & W_3 & 0 & 0\\ 0 & 0 & W_4 & 1\end{bmatrix},$$

Where w1 is the vector of goal or aim effect, for example, selecting the best strategy according to element factors, W2 is the element factors' internal dependence matrix, W3 is the effect matrix of element factors on each of the element sub-factors, W4 is the index of element sub-factors' effect on the strategic options. The matrix functions detail the algorithm steps. The proposed algorithm is derived as follows.

Step 1: Determine the element sub-factors and strategic options according to sub-factors.

Step 2: Assume that no dependencies among element factors exist and then the importance degree of element factors is shown by the numerical scale of 1 to 9.

Step 3: Determine the element factors of the internally dependent matrix by the numerical scale of 1 to 9 and consider other factors by schematic view and internal dependencies among them. (W2 calculation).

Step 4: Specify the internal dependencies' priorities, that is, calculate $^{w}factors = W_2 \times {}^{w}{}_1$

Step 5: Specify the importance degree of element sub-factors using the numerical scale of 1 to 9.

Step 6: Specify the importance degree of sub-factors

Step 7: Specify the importance degree of strategic options, considering each sub-factor, on the scale of 1 to 9.

Step 8: Calculate the final priority of strategic options derived from the internal relationships among element factors. $^{w}alternatives = W_4 \times {}^{w}{}_{sub} - factors\ (global)$

Case Study: the Alupan & Mobarakeh Steel and Irancell Companies: This section presents an illustration of the proposed approach summarized in the previous section. In the following case study, knowledge worker factors analysis utilizing the ANP is performed on the 3 companies.

Alupan: Established in 1974. Its original capacity was 11 000 tonnes and it was situated on a plot of land covering 50 000 square metres, 25 000 metres of which were devoted to production. This company is one of the largest producers in the Middle East of industrial profile sections, aluminium doors and windows and exports much of its production to Europe.

Irancell: Is a private company governed by the Islamic Republic of Iran's commercial code of practice as amended in the year 1347 of the Iranian calendar, which is 1969 in the Gregorian calendar and the provisions of its Articles of Association. The Company was established on the 14 August 2005 [1385/05/23] and the registration number is 252949. The Company has been established for an indefinite period of time. Irancell is comprised of two shareholders who are the Iran Electronic Development Company (IEDC) and MTN International (Mauritius) Limited. The company aims to become the leading power in providing telecommunication and its related to services in Iran.

- Provision of wholesale and retail telecommunication services;
- Sales of network traffic capacity to local or international carriers or entities;
- Rental of network infrastructure facilities to local or international carriers or entities;
- Provision of the Internet data and digital platform's related to all the products and services;
- Provision of all other forms of value added services that is currently available and to be developed in the future;
- Dealing with e-commerce, mobile-commerce activities of the above telecommunication networks;
- Provision of customer services, including but not limited to customer relationship management and Call Centre services

A shareholders Agreement was signed between IEDC and MTN in November of 2005 and the second mobile operator license was awarded to MTN Irancell on 27 November 2005 [1384/09/06] by *MCIT/CRA.

Mobarakeh Steel: Is the largest industrial complex in the Islamic Republic of Iran and has been established and commissioned after the victory of the Islamic revolution and entered into operational stage in early 1993. This company is located at 65 kms from south west of Esfahan which covers a land of 35 kms and has an annul capacity of 4 mt/years of flat steel products ranging in thickness from 0.18 mm to 16 mm in the from of hot and cold rolled coils and sheets, tinplate sheets and coils , Galvanized and prepainted coils.

Table 2: Pair wise comparisons (independent status)

Weight of factors	*F*	*E*	*D*	*C*	*B*	*A*	*Factors*
0.366	4	3	6	5	2	1	A
0.231	5	2	4	3	1		B
0.17	2	4	5	1			C
0.114	3	6	1				D
0.078	5	1					E
0.041	1						F

CR=0.03

The Proposed Algorithm Is Done in the Three Companies as Follows:

Step 1: First, the issue is depicted as a hierarchical structure, which contains the strategic options and sub-factors for the next calculations using ANP. (See Figure 4) The goal is chosen at the first level of the ANP Model and the element factors (identification, creation, acquisition, application, sharing and maintenance) are determined at the second level. The third level contains the three element sub-factors of CAN, WILL and MAY. Furthermore, 13 educational strategic options are given in the fourth level. The educational strategic options are as follows: A-C Spiritual and financial motivation based on the output work level, A-D Authority designation to knowledge workers and awkward rule omission, A-E Communicative and creative environment based on trust, A-F Considering knowledge workers as piece workers, not day workers, B-D Staff training and development, B-E Work cycling in organization, B-F Bonus and evaluation framework for organizational staff, C-D Creating flexible structures, C-E Activity transparency and intellectual property right ownership, C-F Creating suitable informative and communicative structures, D-E Creating collaboration opportunities, D-F Improving organizational atmosphere, E-F Creating job security. Knowledge worker strategies are defined in Figure 4.

Step 2: Assume that there is no dependency among the element factors. Determine the factors' pair comparison matrix using the numerical scale of 1 to 9. (See results in Table 2) All the pair comparisons are completed by a team of experts. The pair comparison matrix (Table 2) is analysed using Expert Choice software and the following special vector is obtained. In addition, a final inconsistency coefficient is shown at the end of the Table.

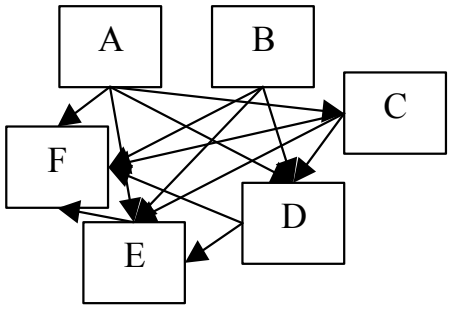

Fig. 5: Internal dependency of factors

$$W_1 = \begin{bmatrix} A \\ B \\ C \\ D \\ E \\ F \end{bmatrix} = \begin{bmatrix} .366 \\ .231 \\ .170 \\ .114 \\ .078 \\ .041 \end{bmatrix}$$

Pair wise comparisons (independent status) are defined in Table 2.

Step 3: The internal dependency among element factors is determined by comparing the effect of each factor on other factors. As mentioned in the preface, considering independence among the element factors is not always possible. Suitable and realistic results are obtained from the ANP technique and element analysis. An analysis of internal and external environment elements reveals the element factors' dependencies as shown in Figure 5. A pair comparison matrix for factors is illustrated in Figures 4 to 6. The results obtained from the special vectors are depicted in the last column of Tables 3 to 8. The internal dependency of the element matrix, based on the calculated relative importance weights, is shown by W2. While opportunities are only influenced by strengths, a pair comparison matrix cannot be formulated for the opportunities. Internal dependency of factors is defined in Figure 5.

Internal dependency matrix of factor A is defined in Table 3.

Internal dependency matrix of factor B is defined in Table 4.

Internal dependency matrix of factor C is defined in Table 5.

Internal dependency matrix of factor D is defined in Table 6.

Internal dependency matrix of factor E is defined in Table 7.

Internal dependency matrix of factor F is defined in Table 8.

Table 3: Internal dependency matrix of factor A

Weights	*F*	*E*	*D*	*C*	*A*
.530	5	7	3	1	C
.310	9	5	1		D
.117	7	1			E
.042	1				F

CR=0.00

Table 4: Internal dependency matrix of factor B

Weights	*F*	*E*	*D*	*B*
.055	1/9	1/5	1	D
.173	1/7	1		E
.772	1			F

CR=0.00

Table 5: Internal dependency matrix of factor C

Weights	*F*	*E*	*D*	*A*	*C*
.565	5	9	3	1	A
.056	1/9	1/5	1		D
.089	1/7	1			E
.290	1				F

CR=0.00

Table 6: Internal dependency matrix of factor D

Weights	*F*	*E*	*C*	*B*	*A*	*D*
.440	5	9	3	3	1	A
.307	7	3	9	1		B
.029	1/5	1/7	1			C
.067	1/9	1				E
.157	1					F

CR=0.00

Table 7: Internal dependency matrix of factor E

Weights	*F*	*D*	*C*	*B*	*A*	*E*
.422	5	7	3	3	1	A
.329	7	5	9	1		B
.039	1/5	1/7	1			C
.078	1/5	1				D
.131	1					F

CR=0.00

Table 8: Internal dependency matrix of factor F

Weights	*E*	*D*	*C*	*B*	*A*	*F*
.490	9	7	3	3	1	A
.249	3	5	9	1		B
.042	1/5	1/7	1			C
.081	1/5	1				D
.138	1					E

CR=0.00

$$W_2 = \begin{bmatrix} 1 & 0 & .565 & .44 & .422 & .490 \\ 0 & 1 & 0 & .307 & .329 & .249 \\ .53 & 0 & 1 & .029 & .039 & .042 \\ .31 & .055 & .056 & 1 & .078 & .081 \\ .117 & .173 & .089 & .067 & 1 & .138 \\ .042 & .772 & .290 & .157 & .131 & 1 \end{bmatrix}$$

Step 4: Priorities for internal dependencies among the factors are calculated as follows:

$$w_{factorsw} = W_2 * W_1 = \begin{bmatrix} 1 & 0 & .565 & .44 & .422 & .490 \\ 0 & 1 & 0 & .307 & .329 & .249 \\ .53 & 0 & 1 & .029 & .039 & .042 \\ .31 & .055 & .056 & 1 & .078 & .081 \\ .117 & .173 & .089 & .067 & 1 & .138 \\ .042 & .772 & .290 & .157 & .131 & 1 \end{bmatrix} * \begin{bmatrix} .366 \\ .231 \\ .170 \\ .114 \\ .078 \\ .041 \end{bmatrix} = \begin{bmatrix} .565 \\ .302 \\ .372 \\ .260 \\ .189 \\ .312 \end{bmatrix}$$

The significant differences observed in the above results when compared with those in Table 2 are due to the lack of information about internal dependencies. Factor priority results including A, B, C, D, E, F have changed from 0.366 FI to 0.565, from 0.231 to 0.302, from 0.17 to 0.372, from 0.114 to 0.260, from 0.078 to 0.189 and from 0.041 to 0.312. Step 5: Local priorities of sub-factors are calculated using the pair comparisons matrix. The priority vector is defined in Appendixes 1, 2, 3. According the priorities, it defines vector of sub factors.

$$W_{sub-fdactors-A} = \begin{bmatrix} 0.308 \\ 0.192 \\ 0.151 \\ 0.133 \\ 0.108 \\ 0.108 \end{bmatrix}, W_{sub-fdactors-B} = \begin{bmatrix} 0.352 \\ 0.181 \\ 0.150 \\ 0.110 \\ 0.150 \\ 0.062 \\ 0.031 \\ 0.028 \\ 0.022 \\ 0.015 \\ 0.009 \end{bmatrix}, W_{sub-fdactors-C} = \begin{bmatrix} 0.35 \\ 0.29 \\ 0.15 \\ 0.13 \\ 0.08 \end{bmatrix},$$

$$W_{sub-fdactors-D} = \begin{bmatrix} 0.255 \\ 0.202 \\ 0.132 \\ 0.123 \\ 0.102 \\ 0.095 \\ 0.085 \\ 0.072 \\ 0.033 \\ 0.028 \\ 0.018 \\ 0.012 \\ 0.008 \end{bmatrix}, W_{sub-fdactors-E} = \begin{bmatrix} 0.208 \\ 0.119 \\ 0.113 \\ 0.122 \\ 0.106 \\ 0.095 \\ 0.084 \\ 0.052 \\ 0.034 \\ 0.025 \\ 0.018 \\ 0.012 \\ 0.008 \\ 0.003 \\ 0.001 \end{bmatrix}, W_{sub-fdactors-F} = \begin{bmatrix} 0.342 \\ 0.211 \\ 0.178 \\ 0.105 \\ 0.077 \\ 0.055 \\ 0.032 \end{bmatrix},$$

Table 9: Final scores of knowledge strategies

Knowledge strategies influencing on Knowledge Worker Productivity	Score
C-E Activity transparency and intellectual property right ownership	0.097
D-E Creating the collaboration opportunities in organizations	0.095
C-F Creating suitable informative and communicative structures	0.089
C-D Creating flexible structures in organization	0.086
A-E Communicative and creative environment based on trust	0.085
A-F considering the knowledge workers as piece workers, not day workers	0.081
A-D Authority designation to knowledge workers and awkward rule omission	0.080
B-F Bonus and evaluation framework creation for organizational staff	0.078
E-F Creating job security in organizations	0.078
A-C Spiritual and financial motivation creation based on the output work level	0.076
B-E Work cycling in organization	0.071
D-F Improving the organizational atmosphere	0.066
B-D Staff training and development	0.063

Step 6: General priorities of the element sub-factors are calculated by multiplying the internal dependency priorities, obtained in Step 4, by the local priorities of element sub-factors, obtained in Step 5. The results are depicted in appendix 1, 2, 3. Vector $^{w}sub{-}factors\ (global)$ which is obtained from the general priority amounts in the last column of appendix 1, 2, 3 is at appendix 4.

Step 7: The degree of strategic options' importance is calculated from each element's sub-factor viewpoints. Special vectors are calculated from the analysis of this matrix and matrix W4 in Appendix 5.

$$w_{alternatives} = \begin{bmatrix} \text{A-C} \\ \text{A}-D \\ \text{A}-\text{E} \\ \text{A}-F \\ \text{B}-D \\ \text{B}-\text{E} \\ \text{B}-F \\ C-D \\ C-E \\ C-F \\ D-E \\ D-F \\ E-F \end{bmatrix} = W_4 * w_{sub-factors(global)} = \begin{bmatrix} 0.076 \\ 0.080 \\ 0.085 \\ 0.081 \\ 0.063 \\ 0.071 \\ 0.078 \\ 0.086 \\ 0.097 \\ 0.089 \\ 0.095 \\ 0.066 \\ 0.078 \end{bmatrix}$$

Step 8: Finally, the general priorities of strategic options are calculated considering the internal dependencies of element factors, as follows:

The general results can be organized from the highest score to the lowest. Then, according to the information in Table 9, they can be analysed.

The results of ANP analysis show that the most important educational strategy for Knowledge Worker Productivity is strategy C-E or Activity transparency and intellectual property right ownership whose score is 0.097. Another important strategy in step 2 is D-E or creating collaboration opportunities in organizations. The significant strategies in step 3 are C-F or Creating suitable informative and communicative structures, C-D or Creating flexible structures, A-E or Communicative and creative environment based on trust, A-F or Considering knowledge workers as piece workers, not day workers, A-D or Authority designation to knowledge workers and awkward rule omission. The important strategies in the fourth step are as follows: B-F Bonus and evaluation framework for organizational staff, E-F Creating job security, -C or Spiritual and financial motivation based on the output level, B-E or Work cycling in organization. The important strategies in the last step are as follows: D-F or Improving the organizational atmosphere, B-D or Staff training and development. It should be mentioned that to improve organization success, all the above-mentioned strategies must be employed. However, in keeping with the company's financial and time constraints, they have been divided into five categories. The project of company has based its current year's programme on the first step or optimum strategy and is affecting reforms based on that. Next year's programme will include all of the above strategies. This method was tested using Cronbach's alpha (its value was more than 98.03); it has been validated and confirmed by 97% of the experts, 98% of the managers and by company directors. The results showed a questionnaire validity of 97.0784%. Its validity was measured using the Cronbach Alpha Coefficient, which equalled 98.3%.

DISCUSSION

This study faced many challenges in its model validation test. The first is that the ANP model's factors are not naturally quantitative. ANP is a technique for solving multi-criteria decision making by using the dependence among quantitative and qualitative factors. However, it is not always possible to apply numerical and quantitative amounts to elements in decision making. It is also that for each calculation, different amounts resulted. This may be due to the different viewpoints among the experts who evaluated the matrix. Thus, it seems impossible to obtain similar amounts based on the data obtained from different studies. These limitations are exacerbated by the nature of decision making. It is natural that in different circumstances, there are different priorities. It should be noted that the existent differences among the pair comparison amounts, which are due to the differences in expert viewpoints, are not sufficient reason for rejecting the proposed model's validity in ANP discussions [20]. Another problem is that the validity of this model has not been tested using the latest data and that is because those data are available only to special managers. The comparison matrix which is the input for the proposed model was composed under definite conditions; hence, results may differ due to the pair comparison matrix's composition in different time periods [22]. This model may be improved as the factors and sub-factors keep changing. Each management team should apply these strategies to the model according to the strategic factors in play. Second, the amount of dependence among factors and sub-factors may vary based on the management type. For example, in The Alupan & Mobarakeh Steel and irancell companies, only the dependence among important element factors is evaluated. The inconsistent ratio resulting from the pair comparison matrix also confirms this model. The inconsistent ratio or CR is based on the inconsistency index and Random index. Inconsistency index or CI can be obtained through the following formula:

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

Where λ_{max} is the highest special amount and n is the matrix dimension. Inconsistency ratio (CR) is composed of two parameters: inconsistency index (CI) and Random index (RI). The relationship between RI and n is as follows: RI = 1.98 * [(n – 2) / n].

Where 1.75 is the ratio of average amount of all numbers for n=3 till n=15, each having been multiplied by (n-2)/n. The calculated amount for the inconsistency ratio in ANP should not be less than 0.1. The inconsistency ratio of the pair comparison matrix is calculated using Expert Choice. All inconsistency ratio amounts are less than 0.1. The most important elements in knowledge workers for Knowledge Worker Productivity are activity transparency and intellectual property right ownership. The organization's compiling the mental ownership document and implementing them is important as well. This analysis of knowledge workers' factors for Knowledge Worker Productivity using the proposed model is the first of its kind and is hence considered unique.

CONCLUSION

We have defined and classified the effective educational factors of knowledge workers for Knowledge Worker Productivity and analysed them using ANP. Consequent to this analysis, we have presented educational strategies for improving knowledge worker productivity, which were verified and validated in a case study of The Alupan & Mobarakeh Steel and irancell companies.

Future Research: One possible follow-up is the comparison of the proposed method with other models, such as the fuzzy topics and neuron fuzzy methods.

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Appendix 1: Sub-factor priorities of A and B

Total Priority of Sub-factors= Priority of Sub-factors* Priority of factors	Priority of Sub-factors	Sub-factors	Priority of factors	Factors
0.1127	0.308	Social intelligence	0.366	A
0.0703	0.192	Academic level		
0.0553	0.151	Job communications		
0.0487	0.133	Specialty		
0.0395	0.108	Training and development		
0.0395	0.108	Information network		
0.0813	0.352	Creation	0.231	B
0.0418	0.181	Innovation		
0.0347	0.150	Experience		
0.0254	0.110	Idea generating		
0.0347	0.150	Oppositions		
0.0143	0.062	Problem solving capability		
0.0072	0.031	Trust		
0.0065	0.028	Competency		
0.0051	0.022	Job opposition		
0.0035	0.015	Independence		
0.0021	0.009	Information network		

Appendix 2: Sub-factor priorities of C and D

Total Priority of Sub-factors=	Priority of Sub-factors	Sub-factors	Priority of factors	Factors
Priority of Sub-factors* Priority of factors				
0.0595	0.350	Authority	0.17	C
0.0493	0.290	Job Commensurability		
0.0255	0.150	Team work capability		
0.0221	0.130	Information network		
0.0136	0.080	Teamwork opportunity		
0.0291	0.255	Experience	0.114	D
0.023	0.202	Commitment		
0.015	0.132	Fidelity		
0.014	0.123	Job communications		
0.0116	0.102	Flexibility		
0.0108	0.095	Organizational culture		
0.0097	0.085	Leadership		
0.0082	0.072	Job Commensurability		
0.0038	0.033	Team work capability		
0.0032	0.028	Incentive system		
0.0021	0.018	Transparent decision-making		
0.0014	0.012	Job rotation		
0.0009	0.008	Intellectual capital salary		

Appendix 3: Sub-factor priorities of E and F

Total Priority of Sub-factors=	Priority of Sub-factors	Sub-factors	Priority of factors	Factors
Priority of Sub-factors* Priority of factors				
0.0162	0.208	Professional ethic	0.078	E
0.0093	0.119	Commitment		
0.0088	0.113	Fidelity		
0.0095	0.122	Social intelligence		
0.0083	0.106	Motivation		
0.0074	0.095	Satisfaction		
0.0066	0.084	Organizational culture		
0.0041	0.052	Trust		
0.0027	0.034	Job security		
0.002	0.025	Competency		
0.0014	0.018	Team work capability		
0.0009	0.012	Organizational climate		
0.0006	0.008	Incentive system		
0.0002	0.003	Job rotation		
0.0001	0.001	Teamwork opportunity		
0.014	0.342	Fidelity	0.041	F
0.0087	0.211	Transparent decision-making		
0.0073	0.178	Storage		
0.0043	0.105	Management information systems		
0.0032	0.077	Communication Infrastructures		
0.0023	0.055	Organizational memory		
0.0013	0.032	Intellectual capital salary		

Appendixes 4: Vector *"sub–factors* (*global*)

$$W_{\text{sub-factors}} = \begin{bmatrix} 0.1127 \\ 0.0703 \\ 0.0553 \\ 0.0487 \\ 0.0395 \\ 0.0395 \\ 0.0813 \\ 0.0347 \\ 0.0254 \\ 0.0347 \\ 0.0254 \\ 0.0347 \\ 0.0143 \\ 0.0072 \\ 0.0065 \\ 0.0051 \\ 0.0035 \\ 0.0021 \\ 0.0595 \\ 0.0493 \\ 0.0255 \\ 0.0221 \\ 0.0136 \\ 0.0291 \\ 0.0230 \\ 0.0150 \\ 0.0140 \\ 0.0116 \\ 0.0108 \\ 0.0097 \\ 0.0082 \\ 0.0038 \\ 0.0032 \\ 0.0021 \\ 0.0014 \\ 0.0009 \\ 0.0162 \\ 0.0093 \\ 0.0088 \\ 0.0095 \\ 0.0083 \\ 0.0074 \\ 0.0066 \\ 0.0041 \\ 0.0027 \\ 0.0020 \\ 0.0014 \\ 0.0009 \\ 0.0006 \\ 0.0002 \\ 0.0001 \\ 0.0140 \\ 0.0087 \\ 0.0073 \\ 0.0043 \\ 0.0032 \\ 0.0023 \\ 0.0013 \end{bmatrix}$$

Appendix 5: W_4 Matrix $W_{4=}$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.05	0.03	0.10	0.01	0.06	0.10	0.11	0.04	0.08	0.10	0.09	0.03	0.05	0.06	0.08
0.11	0.10	0.07	0.05	0.09	0.09	0.01	0.12	0.14	0.06	0.07	0.03	0.06	0.14	0.12
0.09	0.06	0.10	0.08	0.13	0.12	0.01	0.12	0.08	0.11	0.11	0.01	0.04	0.12	0.06
0.08	0.05	0.10	0.11	0.06	0.12	0.03	0.05	0.13	0.05	0.07	0.13	0.15	0.13	0.05
0.04	0.05	0.07	0.01	0.13	0.04	0.04	0.06	0.01	0.04	0.08	0.16	0.01	0.03	0.07
0.08	0.05	0.06	0.11	0.07	0.07	0.09	0.01	0.07	0.09	0.07	0.01	0.08	0.01	0.00
0.11	0.01	0.10	0.03	0.04	0.11	0.08	0.06	0.08	0.16	0.03	0.05	0.05	0.05	0.16
0.06	0.13	0.04	0.15	0.02	0.04	0.14	0.06	0.02	0.04	0.06	0.09	0.12	0.08	0.01
0.09	0.16	0.08	0.10	0.11	0.12	0.12	0.08	0.06	0.01	0.10	0.18	0.12	0.00	0.02
0.06	0.14	0.08	0.10	0.04	0.00	0.12	0.08	0.05	0.14	0.09	0.16	0.15	0.14	0.15
0.12	0.11	0.10	0.11	0.10	0.09	0.16	0.16	0.05	0.04	0.08	0.04	0.09	0.10	0.10
0.01	0.11	0.04	0.05	0.02	0.01	0.08	0.13	0.15	0.04	0.04	0.01	0.08	0.10	0.06
0.12	0.01	0.08	0.09	0.13	0.11	0.01	0.03	0.09	0.14	0.10	0.10	0.00	0.05	0.12
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0.06	0.07	0.05	0.02	0.16	0.04	0.09	0.10	0.08	0.06	0.12	0.17	0.19	0.01	0.05
0.16	0.15	0.01	0.14	0.04	0.00	0.07	0.12	0.07	0.01	0.14	0.10	0.18	0.10	0.06
0.04	0.04	0.10	0.14	0.03	0.05	0.11	0.10	0.00	0.12	0.09	0.09	0.03	0.08	0.10
0.12	0.07	0.10	0.13	0.10	0.09	0.06	0.10	0.08	0.08	0.00	0.07	0.04	0.13	0.10
0.00	0.05	0.01	0.05	0.14	0.10	0.16	0.13	0.04	0.13	0.08	0.08	0.15	0.13	0.08
0.05	0.13	0.08	0.06	0.05	0.10	0.12	0.03	0.13	0.08	0.02	0.02	0.03	0.07	0.05
0.16	0.15	0.05	0.09	0.03	0.07	0.01	0.13	0.16	0.11	0.07	0.07	0.07	0.06	0.10
0.04	0.04	0.17	0.09	0.03	0.13	0.02	0.09	0.04	0.11	0.16	0.07	0.02	0.02	0.07
0.14	0.06	0.13	0.03	0.11	0.13	0.14	0.02	0.07	0.10	0.16	0.05	0.09	0.12	0.05
0.05	0.12	0.02	0.12	0.10	0.15	0.11	0.10	0.11	0.04	0.08	0.12	0.09	0.11	0.10
0.15	0.08	0.02	0.09	0.09	0.07	0.07	0.05	0.14	0.09	0.03	0.01	0.05	0.05	0.10
0.02	0.01	0.16	0.02	0.10	0.00	0.05	0.00	0.03	0.04	0.01	0.15	0.00	0.07	0.11
0.03	0.05	0.12	0.03	0.03	0.06	0.01	0.03	0.07	0.05	0.05	0.01	0.06	0.05	0.03
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
0.17	0.10	0.13	0.10	0.08	0.15	0.05	0.12	0.09	0.11	0.07	0.06	0.12	0.03	0.12
0.07	0.04	0.00	0.03	0.12	0.13	0.07	0.03	0.08	0.09	0.12	0.10	0.04	0.03	0.09
0.11	0.04	0.02	0.06	0.14	0.04	0.14	0.05	0.03	0.11	0.04	0.13	0.09	0.09	0.11
0.06	0.07	0.11	0.11	0.02	0.06	0.03	0.01	0.08	0.02	0.11	0.04	0.03	0.10	0.05
0.01	0.10	0.11	0.12	0.11	0.02	0.05	0.18	0.08	0.09	0.04	0.05	0.05	0.10	0.09
0.20	0.07	0.09	0.06	0.01	0.02	0.15	0.12	0.13	0.08	0.01	0.09	0.08	0.01	0.08
0.05	0.02	0.08	0.13	0.05	0.17	0.10	0.08	0.00	0.08	0.10	0.11	0.08	0.13	0.03
0.01	0.09	0.04	0.00	0.00	0.11	0.05	0.11	0.04	0.09	0.12	0.02	0.08	0.01	0.08
0.17	0.06	0.06	0.09	0.14	0.02	0.01	0.06	0.13	0.10	0.03	0.01	0.08	0.13	0.11
0.02	0.15	0.14	0.08	0.04	0.06	0.03	0.11	0.08	0.04	0.02	0.07	0.09	0.11	0.02
0.02	0.02	0.08	0.03	0.11	0.05	0.15	0.02	0.07	0.09	0.11	0.09	0.12	0.04	0.08
0.05	0.15	0.06	0.08	0.06	0.15	0.03	0.02	0.13	0.03	0.05	0.09	0.01	0.12	0.07
0.06	0.11	0.09	0.12	0.10	0.03	0.15	0.09	0.06	0.10	0.19	0.15	0.11	0.11	0.08
46	47	48	49	50	51	52	53	54	55	56	57			
0.14	0.10	0.03	0.11	0.03	0.14	0.10	0.03	0.11	0.03	0.12	0.07			
0.01	0.02	0.08	0.10	0.12	0.01	0.02	0.08	0.10	0.12	0.04	0.05			
0.07	0.09	0.15	0.06	0.03	0.07	0.09	0.15	0.06	0.03	0.02	0.07			
0.08	0.00	0.02	0.07	0.05	0.08	0.00	0.02	0.07	0.05	0.19	0.01			
0.15	0.01	0.04	0.02	0.10	0.15	0.01	0.04	0.02	0.10	0.03	0.05			
0.05	0.03	0.11	0.06	0.11	0.05	0.03	0.11	0.06	0.11	0.06	0.10			
0.02	0.06	0.02	0.04	0.12	0.02	0.06	0.02	0.04	0.12	0.03	0.09			
0.12	0.06	0.13	0.07	0.04	0.12	0.06	0.13	0.07	0.04	0.14	0.07			
0.05	0.15	0.04	0.09	0.11	0.05	0.15	0.04	0.09	0.11	0.03	0.10			
0.04	0.15	0.03	0.10	0.08	0.04	0.15	0.03	0.10	0.08	0.21	0.14			
0.02	0.01	0.15	0.10	0.12	0.02	0.01	0.15	0.10	0.12	0.06	0.04			
0.11	0.19	0.07	0.07	0.03	0.11	0.19	0.07	0.07	0.03	0.03	0.04			
0.15	0.14	0.13	0.10	0.07	0.15	0.14	0.13	0.10	0.07	0.05	0.17			