Egyetemi doktori (PhD) értekezés tézisei

COMPARISON OF THE METHODS AND A MODEL FOR THE EVALUATION OF THE READINESS IN IMPLEMENTING BUSINESS INTELLIGENCE PROJECTS: A HYBRID APPROACH

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1 Introduction

In recent years, Business Intelligence (BI) systems have consistently been rated as one of the highest priorities of Information Systems (IS) and of business leaders. BI allows firms to apply information to support their processes and decisions by combining its capabilities in both organizational and technical issues. A significant portion of companies' IT budgets is being spent on BI and related technologies. In spite of these investments, the risk of failure in implementing is high and only 24% of BI implementations are identified as being very successful. Hence, the evaluation of BI readiness is vital because it serves two important goals. First, it reveals gaps areas where a company is not ready to proceed with its BI efforts, so by identifying BI readiness gaps, wasting time and resources can be avoided. Second, the evaluation points out what we need to close the gaps and implement BI with a high possibility of success.

This dissertation presents an overview of BI and the necessities for the evaluation of the readiness, and a comparative analysis of the evaluation methods and identifying and ranking the right methods which can be applied in building a model to assess the readiness of organizations. There are many Multiple Criteria Decision Making (MCDM) methods and other further methods which can be applied for building model of evaluation but each of them has its own advantages and disadvantages. By combining and integrating these methods with each other and also with various other methods, we can avoid the disadvantages and improve the model of evaluation. We also examine the MCDM methods in the other unrelated area to show their applicability in order to confirm the validity of our approach in applying these methods for comparison of the techniques and methods. In addition, we provide important and critical

success factors and classify them into two main categories; organizational and technical. Finally, we show process of building the hybrid model by using Interpretive Structural Modeling (ISM) and Graph Theory and Matrix Approach (GTMA) and examine it in a real company as a case study.

Based on the studies, there is not any research of evaluation of BI readiness in companies. So we need to:

i. investigate and determine BI readiness factors and their associated contextual elements that influence implementation of BI systems in companies;
ii. develop a model for evaluation of BI readiness in companies.

2 Proposed approach and models

2.1 The evaluation methods for the readiness

If an available method is chosen arbitrarily, it may result in misleading or even wrong conclusions. To avoid this problem, it is necessary to develop a formal procedure for the selection of the readiness evaluation method for a specific readiness decision problem. There are typically multiple conflicting criteria that need to be evaluated in this kind of decision. Therefore, we face a multiple-criteria evaluation problem. MCDM methods are a well-known approach to solving these problems. So, we applied one of the famous methods of MCDM which is called AHP. Hence, we present a framework by using AHP for the comparative analysis of readiness evaluation methods. Its purpose is to help the authors gain insight into the strengths and weaknesses of the various categories of readiness evaluation methods in order to apply for building

a model to evaluate the readiness of those companies which want to implement BI projects.

2.1.1 Review and classification of the evaluation methods

Methods for readiness evaluation may be broadly classified into three main categories, namely probabilistic method, Multiple Criteria Decision Making (MCDM) methods and hybrid methods, as shown in Figure 2.1.

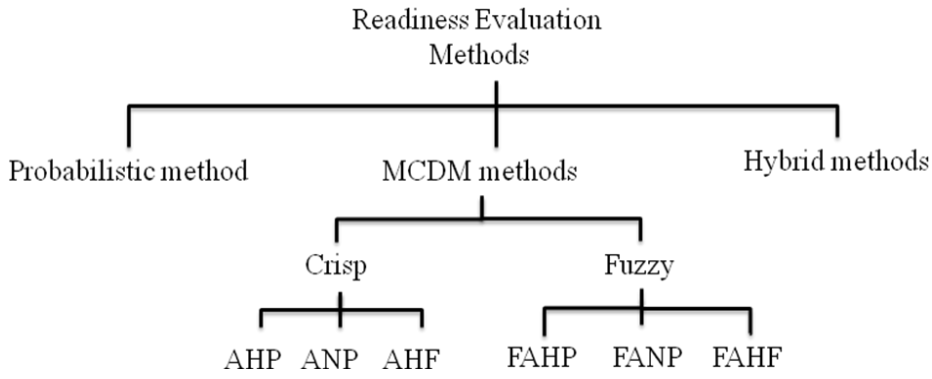

Figure 2.1: Classification of readiness evaluation methods

2.1.2 Framework for comparing readiness evaluation methods

Figure 2.2 depicts the AHP hierarchy for our comparative analysis of the evaluation methods. We intend to perform a comparative study of the identified eight methods and are enumerated at Level 4 of the hierarchy in the figure. At the highest level, we define the goal which is the identification of the ideal or best evaluation method for readiness evaluation. Level 2 lists eight major criteria or factors which are essential in determining the effectiveness of readiness evaluation methods.

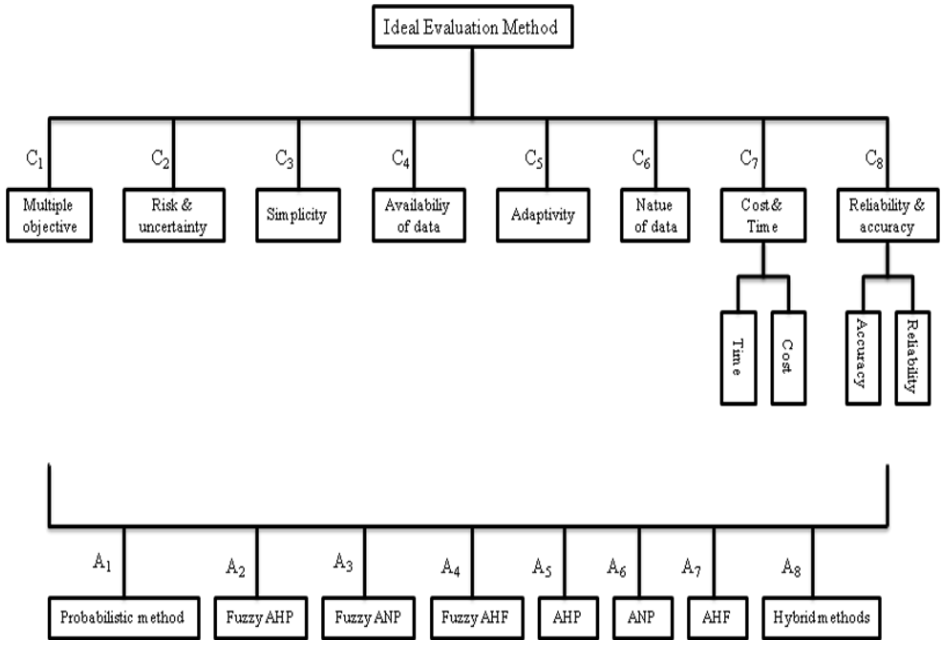

Figure 2.2: Hierarchy for the comparative analysis of the readiness evaluation methods- based on AHP method

2.1.3 Comparison of the readiness evaluation methods

In this step, the experts include seven specialists (three BI project managers, two BI experts and two BI academicians) who shall compare the criteria at Level 2 with respect to the overall goal at top level by assessing the importance of each criterion in relation to the choice of evaluation methods. Following the AHP methodology, the experts performed pairwise comparison to obtain the relative importance of the factors.

The analysis indicated that the criterion 'Multiple objective' has the highest weight of 26%, followed by criteria 'Reliability and Accuracy' and 'Risk and Uncertainty' which have weights of 19% and 18%. This prioritization is consistent with the very nature of real-world readiness

evaluations and is usually multiple objective and a company typically has more than one objective in an evaluation program. The quality of being reliable and accurate is a necessity for every evaluation method. Also, the readiness evaluation methods usually incorporate risk and uncertainty in analysis.

The result of performing pairwise comparisons on the alternative methods with respect to each criterion depicts that the hybrid methods have the highest weight of 0.211, and with large gap, we have the probabilistic method in the second rank with a weight of 0.124, and it is closely followed by the AHP with a weight of 0.122. The rest of the readiness evaluation methods in decreasing importance have approximately equal weights which means there is not meaningful difference among them.

So, this comparative study depicts that the hybrid methods are the most favorable methods for building the evaluation models.

2.2 AHP and AHP-Fuzzy TOPSIS methods

In this section, we want to show applicability of AHP and AHP-Fuzzy TOPSIS methods in building a model to compare techniques and methods in the other unrelated area of BI in order to prove correctness of our way in comparing the techniques.

Identifying the right technique for solving a reactive scheduling problem in operating rooms is an area of considerable interest to both academics and practitioners. Therefore, the authors tried to offer a broad summary of the most common techniques which can be used to solve the problem and conduct a comparative analysis of the techniques. We apply AHP

method and AHP-Fuzzy technique for order preference by similarity to ideal solution (TOPSIS) as the frameworks for our comparative analysis of reactive scheduling techniques. These methods enable us to compare and rank the alternatives based on both qualitative and quantitative factors.

2.2.1 Review and classification of the solution techniques

The solution techniques for reactive scheduling problems may be broadly classified into ten main categories, namely: heuristics, meta-heuristics, branch and bound algorithm technique, integer programming, knowledge-based systems, fuzzy logic, neural networks, Petri nets, multi-agent systems, and hybrid techniques. Figure 2.3 displays these main categories with their sub-categories.

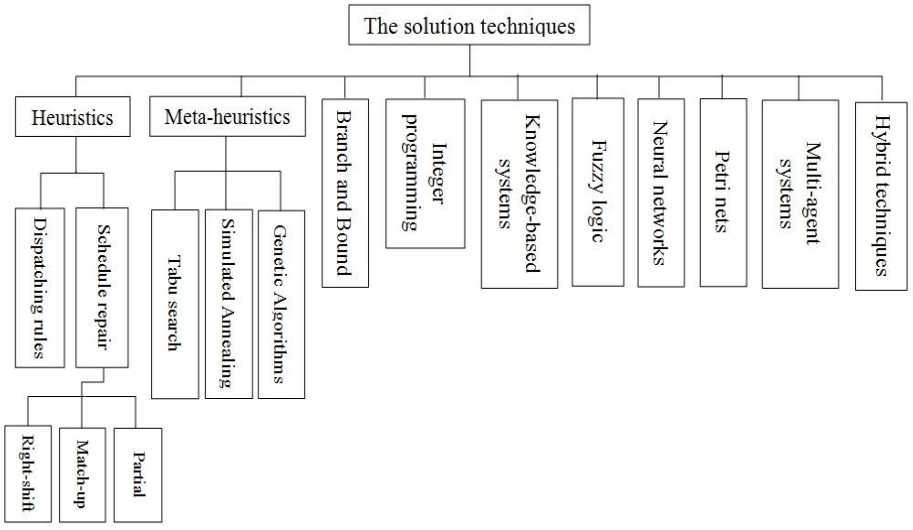

Figure 2.3: Classification of the solution techniques

2.2.2 Application of AHP in ranking the solution techniques

Figure 2.4 illustrates the AHP hierarchy for our comparative analysis of the solution methods. We perform a comparative study of the ten previously introduced techniques that have been listed at level 3 of the hierarchy. At the highest level, we specify the goal which is the identification of the ideal or best solution technique for solving reactive scheduling problems in operating rooms. Level 2 enumerates eight major and essential criteria for determining the effectiveness of solution techniques. Based on the AHP methodology and specifications of techniques, pairwise comparisons have been performed and the weights have been determined by specialists of scheduling and the related techniques (six academicians who have focused on scheduling problem in operating rooms).

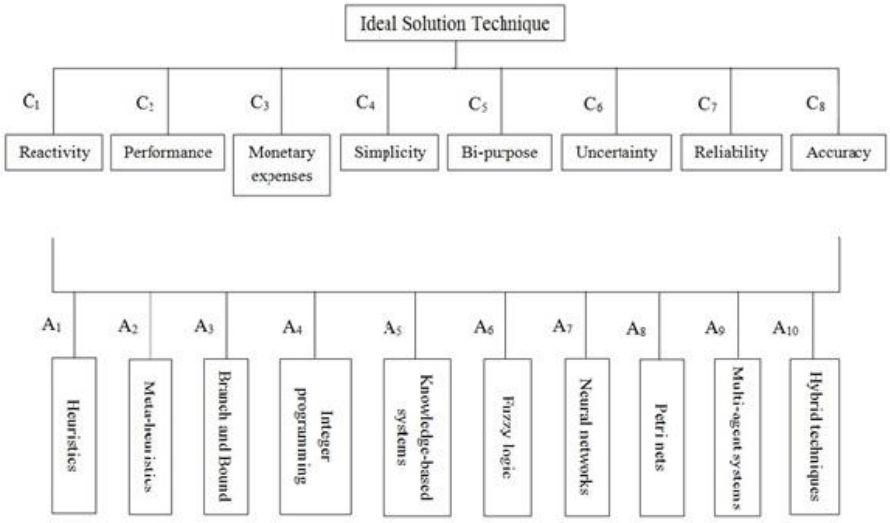

Figure 2.4: Hierarchy for the comparative analysis of the solution techniques- based on AHP method

The specialists individually judged their best upon their experiences in applying the techniques. It is evident that the results of the study could not be the same exactly when the pairwise comparisons are accomplished by different experts.

The results demonstrate that the 'Reactivity' criterion has the highest weight of 19%, followed by criteria 'Performance' and 'Bi-purpose' which have weights of 18% and 17%, respectively. This prioritization is consistent with the nature of real-world reactive scheduling problems in operating rooms since online reaction and performance and supporting both of elective and non-elective patients are essential capabilities for every technique in solving the real problems. Reliability is a necessity for each and every solution technique. Moreover, not only the solution techniques must be accurate with high precision but also, they must be able to incorporate with risk and uncertainty in analysis.

After accomplishing pairwise comparisons on the alternative techniques with respect to each criterion at level two in continuing and processing down the hierarchy, the analysis depicts that the branch and bound technique has the highest weight of 0.238, and we have integer programming technique in the second rank with a weight of 0.188, and the hybrid techniques with a weight of 0.132 are in the third rank, and it is closely followed by the heuristics with a weight of 0.125. The rest of the solution techniques in decreasing importance are meta-heuristics with a weight of 0.083 and the four techniques (fuzzy logic, knowledge-based systems, multi-agent systems, and neural networks) have approximately equal weights which mean there is not any meaningful difference among them and finally, the Petri nets with a weight of 0.028 is in last rank.

2.2.3 Application of AHP-Fuzzy TOPSIS in ranking the techniques

The extracted weights from AHP are included in fuzzy TOPSIS computations and the solution technique priorities are determined. We followed the basic steps in Fuzzy TOPSIS method:

Table 2.1 depicts the ten solutions techniques and their ranks. Also, Figure 2.5 in the form of a bar chart shows a graphical comparison of the overall priorities.

Table 2.1: Final ranking of the techniques

Rank	Technique	Coefficient
1	Branch and bound	0.6743
2	Integer programming	0.5665
3	Hybrid techniques	0.4520
4	Heuristics	0.3459
5	Meta-heuristics	0.2652
6	Fuzzy logic	0.2302
7	Knowledge-based systems	0.1967
8	Multi-agent systems	0.1834
9	Neural networks	0.1765
9	Petri nets	0.1765

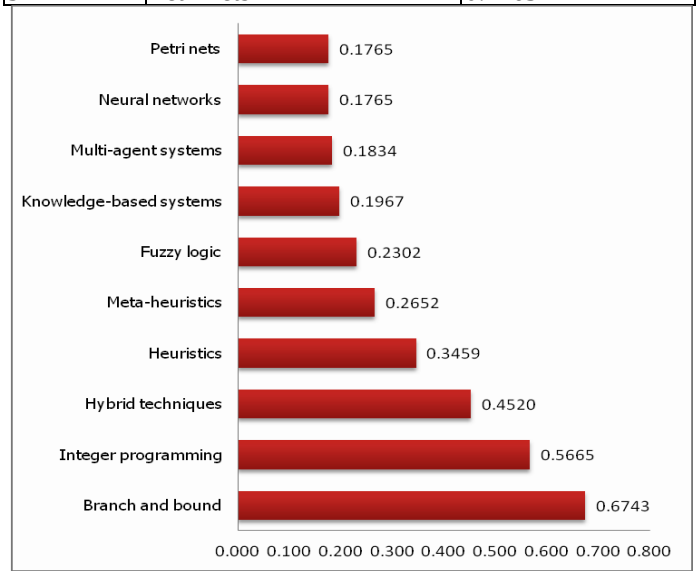

Figure 2.5: The comparison for the ten solution techniques

2.3 Proposed hybrid method and model

According to the results of studies which show the hybrid methods are the most favorable methods for building the evaluation models of BI project, combination of ISM and GTMA are considered in this dissertation for assessing the organization's readiness. Overall, the main contribution of this section is the usage of the ISM method to depict the relationship between the involved key factors (the critical organizational and technical factors) in a successful implementation of BI projects. Then by using the Graph Theory and Matrix Approach (GTMA), obtain an indicator to evaluate the organization's readiness before implementing BI projects.

2.3.1 The critical organizational and technical factors

Figure 2.6 provides a summary of the factors. Of course, the names of factors are selected based on their similarities in concepts and definitions.

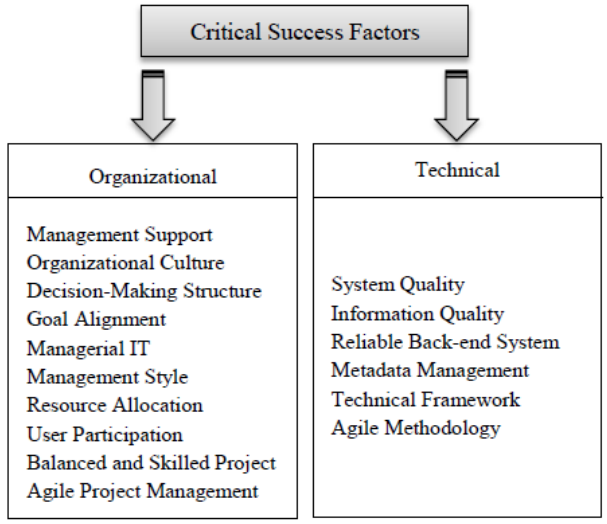

Figure 2.6: The Critical Success Factors

Farrokhi and Pokorádi believed that these factors should be carefully considered by senior managers and BI project managers of companies that are evaluating the readiness of their organizations. These factors are used in our hybrid method.

2.3.2 The BIIAR model

Index to assess readiness of organization for the successful implementation of BI is achieved by using the Permanent matrix, from the following equation:

BIIAR[1] = the numerical value of the Permanent matrix of factors.

The time complexity of this formula is *O(N*N!)* and it is not appropriate in cases where *N* is high. Therefore, we utilized the optimized algorithm which has higher execution speed *(O(N^2 2^N))*. This formula is as follows:

$$per(A) = \sum_{t=0}^{n-1} (-1)^t \sum_{x \in \tau_{n-t}} r_1(X) r_2(X) \dots r_n(X)$$

where

$$\tau_k = \{X \epsilon R^{n \times k} \mid X \; consists \; of \; columns \; of \; A\}$$

and

$$r_i(X) = sum \; of \; row \; i \; of \; matrix \; X$$

We adapted above algorithm and wrote it in C# and all calculations were done.

[1] **B**usiness **I**ntelligence **I**ndex of **A**ssess **R**eadiness

2.3.3 Works done

The two series of questionnaires were prepared according to these CSFs. The first questionnaire was related to the ISM and the second one is for GTMA. To check the reliability and validity of the questionnaires, we calculated Cronbach's alpha, which was 0.885 and also experts confirmed the accuracy of the questionnaires.

Then questionnaires were completed by several specialists (five experts plus two academicians) in BI field. Relations between factors were extracted by applying ISM method and according to the experts' answers of the first questionnaire. Final Reachability Matrix and Factor Levels resulted from ISM method have been brought.

To apply GTMA, first we obtain the adjacency matrix of the ISM model. Then to create matrix **H**, we form matrixes **E** and **F** by using the adjacency matrix of ISM model and the results of the second questionnaire. **E** is a diagonal matrix with diagonal elements e_i, which indicates the importance of factors. The importance of factors was derived from the questionnaires completed by professionals. **F** is a matrix which non-diagonal elements show the importance of one factor to another factor instead of 1 value in the adjacency matrix of ISM model. These values are derived from the second questionnaire too. Given the matrixes **E** and **F**, the matrix **H** is obtained according to the Equation.

Finally, permanent function applied to H matrix and BIIAR is obtained. This index shows the readiness of organization to implement BI.

In this study, we examined the utility organization with about 1,000 employees, which covers two provinces and has the task of electricity

transmission. The researchers believe that utilities industry is an environment where decisions are time sensitive and focusing on BI for utilities can be important for this industry. The calculated BIIAR for the company is as follow:

$$BIIAR = 21.35 \times 10^{17}$$

For interpreting of the sample company's readiness, we have to calculate the best and the worst conditions of the readiness. In the best condition of the readiness which can be ideal for the company, it is when all of quantities of the final matrix are equal with 9 which the output of algorithm will be 3.87770e+28. If the resulted number be closer to this number, we can conclude that company's condition of the readiness is more desirable.

The worst condition is when all of quantities of the final matrix are equal with 1 which the output of algorithm will be 2.0923e+13. Therefore, if the resulted number be closer to this number, it shows that the company's condition of the readiness is more undesirable.

As we mentioned, the sample company's BIIAR is equal with 2.1350e+18 which is close to the worst condition. So, this company is not ready for implementing BI project.

3. Contributions

The most important scientific contributions of the doctoral thesis are:

1. This dissertation has been shown the necessities for building a model to evaluate BI projects via a comprehensive literature review. We expressed the necessity of investigation and

determination of BI readiness factors and their related items which effect on implementation of BI systems in companies and also a need to build a model in assessing BI readiness. We published this state of the art survey in [1];[7] and discussed regarding them. Citations of our survey in a number of publications including Elsevier and others (more than twenty) have motivated the further investigations on this realm.

2. An overview of BI and it's components in form of architecture has been depicted. Basically, for better understanding BI and its component, we need to address in way which be useful to the people. One of the best ways for expressing is architectural form. Hence, we used this way and demonstrated the architectures and described components of the conventional and the new-generation architectures as well. In our published study [F1], we demonstrated the architectures well.

   [F1] V. Farrokhi and Pokorádi, L., "Business Intelligence and its components: An Architectural View," in *First International Conference on Computer Science, Engineering, Technology & Applications*, 2012.

3. We provide a better understanding of the important and critical success factors via conduct a survey and comprehensive study of the critical factors in evaluation phase of the readiness by classifying the factors into two main categories; organizational and technical. Hence, we offer a broad summary of the most common and impact factors which can influence in implementing BI projects. It is valuable to determine these factors, particularly for managers of those companies are involved in implementing BI projects and they face to evaluate readiness of their organizations

before launching the project in pre-implementation stage. We published this study in [6];[9].

4. Determining the right method for developing a model to evaluate readiness of organizations in implementing BI projects is done with offering a summary of the most common evaluation methods and comparing the methods based on their features and suggests a suitable method. We built a model to this comparison by using AHP method. The proposed method is published in [3] which demonstrate the hybrid method and approach can assist us in the evaluation.
5. For showing applicability of AHP and AHP-Fuzzy TOPSIS methods in other unrelated areas, they are applied in ranking the techniques for solving reactive scheduling problem in operating room. It confirms the validity of our approach in applying these methods for comparison of the techniques and methods to the evaluation. We published one study in [2] and other one is submitted to a well-known journal [F2] and under revision. This work was the part of PhD study in Université de Lorraine (France) as scholarship opportunity which helps us in the research.

   [F2] Farrokhi V., Herrmann F., Kacem, I., Pokorádi L.: An overview of reactive scheduling problem for operating room and a comparative analysis of the solution techniques, Computers & Industrial Engineering(under revision).

6. We provide a method to evaluate the key factors for the successful implementation of BI projects and to determine the organization's index of assess readiness before the implementation of BI projects. We apply a combination of

Interpretive Structural Modeling (ISM) and Graph Theory and Matrix Approach (GTMA) on the factors to earn an indicator for evaluating the organization's readiness for implementing a BI project. We applied this method in an organization and determined the organization's readiness before the implementation of BI and found it to be very effective. The study is submitted in a famous Hungarian journal [F3] and under revision.

[F3] Farrokhi V., Pokorádi L., Bouini S.: The organizational and technical key factors identification for Business Intelligence projects implementation using an integrated Interpretive Structural Modeling, Graph Theory and Matrix Approach, Acta Polytechnica Hungarica (under revision).

4 Summary

Previously, decisions were made by senior management in organizations and were based solely on personal experience, leading to increased risk in decision making. Nowadays, however, most companies are moving towards BI systems. It is estimated that technology budgets dedicated to Business Intelligence in 2006, increased from $ 14 to $ 20 billion. Experiments have shown that the probability of failure in BI projects is high and evaluation before the start of implementation is important, because if the company is not assessed, the implementation of BI projects can cause waste of time and resources and the company will not achieve the expected profit.

The thesis has achieved its goals: building the models for comparative analysis the methods and techniques which are applicable in the related and unrelated areas of BI and also building a model for evaluation of the readiness in implementing BI projects via a hybrid approach.

5 Suggestions for Future Works

Our suggestions for future works which can be related to this study are: comparing the appropriate methods and techniques with other suitable MCDM methods to choose the best method for building a model and compare the results of the various ways. Ranking of the CSFs with the use of other methods include MCDM methods can be interested to both academicians and practitioners.

As we know, the algorithm will produce different results according to any society's culture and economy. Our suggestion is to implement proposed algorithm in an organization that has implemented BI successfully. Then the BIIAR rate can be obtained for that organization will be a standard for other organizations in that society. Also, we can use the average from BIIARs of several successful organizations as a measure to obtain more accurate standard.

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List of publications related to the dissertation

Foreign language Hungarian book chapters (1)

1. **Farrokhi, V.**: An overview of business intelligence and necessities for evaluation of readiness in implementing BI projects.
   In: Proceedings of "Challenges and Lessons in Management" International Conference on the Occasion of the 40th Anniversary of the Foundation of the Department of Management and Enterprise. Ed.: Szűcs Edit et al, Debreceni Egyetem, Debrecen, 1-8, 2012. ISBN: 9789634735939

Foreign language international book chapters (2)

2. **Farrokhi, V.**, Kacem, I., Pokorádi, L.: Ranking the solution techniques for reactive scheduling problem in operating room.
   In: 2014 International Conference on Control, Decision and Information Technologies (CoDIT). Ed.: Imed Kacem, Pierre Laroche, Zsuzsanna Róka, IEEE, Piscataway, 001-006, 2014. ISBN: 9781479967735

3. **Farrokhi, V.**, Pokorádi, L.: A comparative analysis of evaluation methods for readiness of business intelligence project.
   In: Proceedings of the XIIIth Conference on Mathematics and its Applications, University "Politehnica" of Timisoara, November, 1-3, 2012. Ed.: Cuculescu, Ioan [et. al], Editura Politehnica, Timisoara, 229-234, 2012, (1224-6069)

Foreign language scientific articles in international journals (4)

4. Babazadeh, M., **Farrokhi, V.**: Flexible, multi-regional database usage of a new computer-aided relay coordinator.
   Int. J. Appl. Math. Electron. Comput. 4 (2), 39-44, 2016. EISSN: 2147-8228.

5. Babazadeh, M., **Farrokhi, V.**, Pour Eskandari, M.: Requirement of a new substation based protective relay coordination.
Int. J. Appl. Math. Electron. Comput. 4 (1), 17-23, 2016. EISSN: 2147-8228.

6. **Farrokhi, V.**, Pokorádi, L.: Organizational and technical factors for implementing business intelligence.
An. Oradea Univ. Fasc. Manag. Techn. Engineer. 22 (1), 75-78, 2013. ISSN: 1583-0691.

7. **Farrokhi, V.**, Pokorádi, L.: The necessities for building a model to evaluate business intelligence projects: literature review.
Int. J. Comput. Sci. Eng. Surv. 3 (2), 1-10, 2012. ISSN: 0976-3252.

List of other publications

Foreign language Hungarian book chapters (1)

8. Azodinia, M., **Farrokhi, V.**, Hajdu, A.: Constant time median filtering of extra large images using Hadoop.
In: Proceedings of the 9th International Conference on Applied Informatics January 29 - Februar 1, 2014. Eger, Hungary Volume I [elektronikus dokumentum]. Ed.: by Kovács Emőd, Kusper Gábor, Kunkli Roland, Tómács Tibor, Eszterházy Károly Főiskola, Eger, 93-101, 2015. ISBN: 9786155297182

Foreign language international book chapters (1)

9. **Farrokhi, V.**, Pokorádi, L.: Organizational and technical factors for implementing business intelligence.
In: IMT Oradea - 2013 : Proceedings of the annual session of scientific papers : May 30 - June 1 2013, Felix SPA, Oradea Romania. Ed.: Calin Baban [et al.], Editura Universitatii, Oradea, 257-260, 2013. ISBN: 9786061010844

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of Web of Science, Scopus and Journal Citation Report (Impact Factor) databases.

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