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Business Intelligence System Selection with Ahp-Vikor Methodology

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Abstract

Increasing amount of data and the need for analysis of this data have made the concept of Business Intelligence System (BIS) more important to plan the future of businesses. BIS is a set of technologies, processes, methodologies, and architectures that enable the processing of large amounts of data and their transformation into a high-quality information. Companies implement BIS for monitoring business processes, receiving reports on systems operation, distributing the right information in the right way to the right people at the right time and analysing business indicators. However, the selection and implementation of such systems can be very challenging. Therefore, the aim of this study is to propose an evaluation model with Multi Criteria Decision-Making (MCDM) techniques for selecting the most appropriate BIS. Analytic Hierarchy Process (AHP) method is applied to find the weights of influencing factors. Finally, the most appropriate BIS alternative is selected from different alternative BI vendors by implementing VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje, meaning: Multicriteria Optimization and Compromise Solution) method. An application is provided to test the applicability of the proposed methodology. Finally, the results of the application are given and the future perspectives are presented.

Keywords: AHP, Business intelligence, Business intelligence systems, MCDM, VIKOR

1. Introduction

Nowadays businesses have different dimensions on which any organization get the unique place in customers' eyes. Accordingly, Business Intelligence (BI) is one of the most important dimensions nowadays. BI is a technology-driven process that informs an organization's tactical and strategic business decisions. BI technologies provide users detailed intelligence about their state of the business by presenting historical, current and predictive views (Pratt, 2017). BI enables informed decision making as well as problem identification and resolution by observing historical data from multiple sources and accessing real-time data.

Business Intelligence System (BIS) is fundamentally about transforming organization's operational data into a high quality, accessible information. BIS aims to distribute the right information, to the right people in the right way, at the right time. BIS continues to be a growing and highly competitive area since it helps the organization to flow the business data among the different department as a common entity (Endo et al., 2016). However, the selection of the most appropriate BIS is very crucial and many influential factors affect this selection process.

First, companies that intend implementing BIS should understand the vision and mission of their organization. Then, managers or executives need to answer these following questions: (1) Why do our organization should implement BI? (2) What are our organization's business requirements? (3) What is our organization's return on investment from this implementation? (Ngai et al., 2008).

The aim of this study is to propose a model for BIS selection problem by using analytical techniques. In this study, we employed Multi Criteria Decision-Making (MCDM) techniques to select the most appropriate BIS alternative. We implemented an integrated Analytic Hierarchy Process (AHP) and VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje, meaning Multicriteria Optimization and Compromise Solution) methodology. AHP is used to determine the criteria weights while and VIKOR is used to rank the alternatives. In the related literature, we observed that, there is a few studies integrating BIS selection with analytical framework. Therefore, this paper contributes to literature by proposing an integrated MCDM framework to BIS selection area.

The remainder of this paper as follows: Second section summarizes the comprehensive literature review about this subject. Section 3 provides the research methodology and proposed model. Section 4 present an application of the methodology. Finally, Section 6 provided concluding remarks and future perspectives.

2. Literature Review

2.1. Literature Review of BIS

We decided to restrict our search by using “business intelligence system” keyword and we have found 156 studies on “Web of Science“. Some of these studies were examined in this study to take advantage.

Vukšić et al.(2010) emphasized the importance of business process management and BIS. Nofal & Yusof (2013) reviewed the articles published between 2000 and 2012 regarding the integration of BI and ERP. Antoniadis et al. (2015) examined the implementation of ERP systems and the expansion of BI usage.

Kubina et al. (2015) described the possibility of improving efficiency by using BIS. Peters et al. (2016) developed a theoretical model that considers three concepts of BI quality as: performance measurement, organizational learning and the knowledge-based view of the firm. Ram et al. (2016) investigated the role and implication of Big Data analytics on BI for the data collected from social media channels.

Vajirakachorn & Chongwatpol (2017) described a way for integrating a BI framework to manage and turn data into insights for festival tourism. Polyvanyy et al. (2017) represented a framework for devising process querying methods and models that describe relationships between processes. Recently, Janković et al. (2018) proposed a model as a basis of big data analytics integration in EIS.

2.2. Literature Review of BIS and MCDM

Secondly, we searched the “Web of Sciences”, “Science Direct” and “Google Scholar” databases with “business intelligence AND MCDM” keyword and we have found 7 studies. The detailed information about these studies are provided in Table 1.

Table 1: Studies concerning BIS and MCDM

Year	Author(s)	Aim of the Study	Methods	Application Area
2017	Hanine et al.	To propose integrated methodology for Geospatial BI selection	Modified Delphi, Fuzzy AHP, PROMETHEE	Geospatial BI selection
2016	Hanine et al.	To propose integrated MCDM methodology for selection problem	AHP, TOPSIS	ETL software selection

2015	Wang	To present an integrated framework to help business planners	Fuzzy Delphi, Fuzzy DEMATEL, Fuzzy AHP, QFD	Supplier recommendation
2014	Martin et al.	To present an information delivery model for banking business	Fuzzy AHP	Banking business
2012	Rouhani et al.	To propose a new model to present a basic approach assessing enterprise systems in BI aspects	Fuzzy TOPSIS	Enterprise systems
2010	Chen and Wang.	To propose a framework built on specific business operation factors	Fuzzy Modified Delphi, Fuzzy AHP	Information services
2009	Lin et al.	To assess the effectiveness of BIS	ANP	Computer supplier

In the literature, although many studies have been done on BI, there is not much work done about BIS selection with MCDM methods. Lin et al. (2009) formulated an Analytic Network Process (ANP) based on assessing the effectiveness of BIS. Rouhani et al. (2012) represented a new model to provide a new approach to evaluate institutional systems in BI aspects. Wang (2015) proposed a fuzzy multi-criteria decision making (MCDM) based Quality Function Deployment (QFD) support system to aid to supplier recommendation for BIS. Hanine et al. (2016) proposed an integrated methodology for the evaluation of Geospatial BI alternatives.

Therefore, since there is a few number of studies integrating BIS selection and MCDM tools, there is a gap in literature for those frameworks. In this study, we aim to fill this literature gap by proposing a BIS selection framework that consists of new criteria and alternatives and to combine this framework with MCDM techniques.

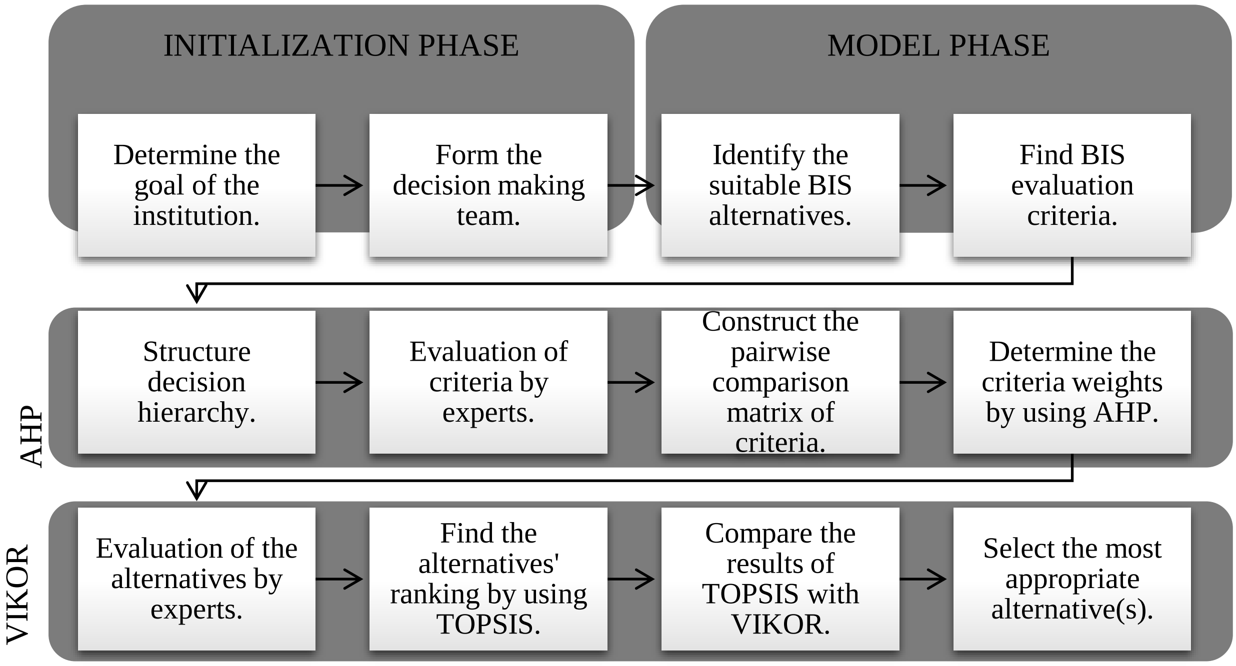
3. METHODOLOGY AND MODEL

3.1. Research Methodology

In this study, we aim to answer the question of: “How to apply MCDM for BIS selection?” To answer this question, we employed the methodology illustrated in Figure 1.

In the first phase of the study, the goal is defined and decision-making team is constructed. To construct the selection model, the suitable BIS alternatives and the evaluation criteria are determined in the model phase. Then, AHP method is implemented to find the importance degrees of criteria. In the ranking phase, TOPSIS and VIKOR methods are selected to rank BIS alternatives, accordingly, their results are compared.

Figure 1: The research methodology of the study



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3.1.1. AHP Method

AHP was developed by Saaty (1980) and it is a model which issued very often in decision-making problems. This methodology aims to prioritize different criteria. To make an organizational decision to generate priority, we must resolve the decision with the following steps Saaty (1980):

Step 1. The problem and the type of information searched are determined.

Step 2. The hierarchy of decision from the top with the aim of the decision, then the criteria and sub-criteria to the lowest level is constructed.

Step 3. Pair of comparison matrix sets is constructed. Each item in the top level is used to compare items in the level just below it.

Comparison matrix *A* is constructed. Every input a_{jk} of the matrix *A* represents the significance of the j^{th} criterion relative to the k^{th} criterion. The inputs a_{jk} and a_{kj} satisfy the constraint:

$$a_{jk}.a_{kj} = 1 \quad (1)$$

Table 2: Table of relative scores (Saaty, 1980)

Value of a_{jk}	Interpretation
1	*j* and *k* are equally important
3	*j* is slightly more important than *k*
5	*j* is more important than *k*
7	*j* is strongly more important than *k*
9	*j* is absolutely more important than *k*

To make comparisons, we need a number of measures that show how many times an item is more important than another item. Table I shows the AHP scale of comparing.
After the construction of matrix *A*, the normalized pairwise comparison matrix A_{norm} is built by making the sum of the inputs on each column equal to 1, each input of the matrix A_{norm} is calculated as:

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{jk}} \quad (2)$$

The vector of criterion weight(w) is constructed by taking the average of the entries on each row of A_{norm} as:

$$w_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m} \quad (3)$$

Step 4. The preferences from the comparing to weigh the preferences at the level just below are used for each item. Then, the weighing values for each item at the level below are added and global or global priority are taken. This weighing and dispensing process continues till the final priorities of the alternatives at the bottom level are reached (Işıklar and Büyüközkan, 2007).

Step 5. The decision maker's decisions should be consistent during the evaluation phase. In order to provide this condition a consistency ratio is computed. The inconsistency index (consistency ratio) is calculated with the equation:

$$CI = \frac{\lambda_{max} - N}{N-1} \quad (4)$$

3.1.2. VIKOR Method

VIKOR method was introduced by Opricovic & Tzeng (2002). This methodology solves decision-making problems with the the Lp-metric concept (Opricovic & Tzeng, 2004). This method aims to rank and choose from number of alternatives (Chiu et al., 2013). It is a technique for optimization of complicated systems with multi-criteria because it considers different conflicting criteria concept (Opricovic & Tzeng, 2004). The alternatives are defined as a1,a2, ..., aJ. For alternative aj, the rating of the ith aspect is indicated by fij (ith criteria function for the alternative aj) (Dag & Önder, 2013):

Step 1. The ideal f_i^* and the worst f_i^- values of all criteria functions (i=1,2,…,n) with respect to benefit or cost functions are determined. If the ith function symbolizes a benefit, then:

$$f_i^* = max\, f_{ij}\,, \quad f_i^- = min\, f_{ij} \quad (5)$$

If the *ith* function symbolizes a cost, then:

$$f_i^* = min\, f_{ij}\,, \quad f_i^- = max\, f_{ij} \quad (6)$$

Step 2. The values *Sj* and *Rj*, *j=1,2,...,J*, are calculated by:

$$S_j = \sum_{i=1}^{n} w_i \frac{(f_i^* - f_{ij})}{(f_i^* - f_i^-)} \quad (7)$$

$$R_j = max\left[wi \frac{(f_i^* - f_{ij})}{(f_i^* - f_i^-)}\right] \quad (8)$$

Where w_i refers to weights of criteria, expressing their relative significance.

Step 3. The values Q_j, *j=1,2,...,J*, are calculated by:

$$Q_j = v\frac{(S_j - S^*)}{(S^- - S^*)} + (1-v)\frac{(R_j - R^*)}{(R^- - R^*)}$$
(9)

where

$$S^* = minS_J, \quad S^- = maxS_j$$

(10)

$$R^* = minR_J, \quad R^- = maxR_j$$
(11)

where v refers to the weight for the strategy of the maximum group utility, whereas 1-*v* is the weight of the individual regret. In this study the value of *v* is taken as 0.5.

Step 4. The *S, R* and *Q* values are sorted in decreasing order. The results consist of three lists of ranking.

Step 5. A compromise solution the alternative (a') which is best by the minimum *Q* value is suggested if these two circumstances are satisfied:

C1. Acceptable Advantage:

$$Q(a'') - Q(a') \geq DQ$$
(12)

where a″ is the alternative in second position in the ranking list by *Q ; DQ = 1/(J -1);* J is the number of alternatives.

C2. Acceptable stability in decision making:

The best ranked by *S* or/and *R* values is also must be alternative a′ . This compromise solution is consistent with the decision-making process.

- If one of the conditions is unsatisfactory, a set of compromise solutions is suggested and the solution(s) are:
- If only condition C2 is unsatisfactory, alternatives a′and a″
- If condition C1 is unsatisfactory, alternatives $a', a'', \dots, a^{(M)}$ and $a^{(M)}$is determined by the relation $Q(a'') - Q(a') < DQ$ for maximum *M.*

The best alternative is the one with the lowest *Q*, ranked by *Q*. The main sorting outcome is a number of alternatives based on reconciliation and a compromise solution with the "advantage ratio".

3.2. Proposed Model

3.2.1. Alternatives

According to Gartner's "Magic Quadrant for Analytics and Business Intelligence Platforms, 2018" report, BIS in the market are illustrated in Figure 2.

Therefore, the evaluation BI alternatives in this paper are assigned as Microsoft, Tableau, Qlik and Sisense. However, different alternatives have their own attributes on big data's 5V's (i.e. volume, velocity, veracity, variety, value).

Figure 2: Gartner's Magic Quadrant for BIS, 2018
(Source: Gartner, The 2018 Analytics and BI Magic Quadrant Highlights)

The main features of this alternatives are summarized as:

- A1. Microsoft: Microsoft offers gaining deeper insight into data by integrating SQL Server 2017, Azure Analysis Services, and Power BI. This integration brings together powerful BI capabilities for capturing business insights and sharing across the company by transforming complex data (URL1).

- A2. Tableau: Tableau promises to harness the power of the data, to unleash the potential of the people by choosing the analytics platform that disrupted the world of BI (URL2).

- A3. Qlik: Qlik offers with the only end-to-end analytics and data management. It means that, transforms the entire organization daily (URL3).

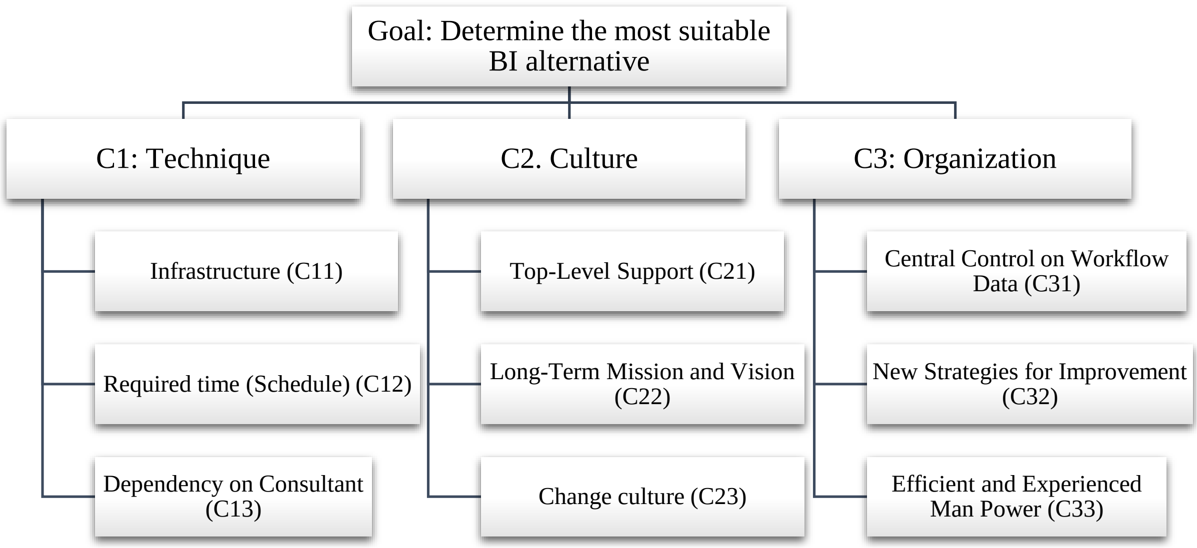
- A4. Sisense: Sisense's BI software aims to easily and instantly capture business insights from any size complex data that exist in any data source (URL4).

3.2.1. Criteria

IT-enabled analytic content development is necessary for a modern BI platform supports. It has a self-contained architecture that provides users to autonomously execute analytic workflows and the collaborative sharing of insights (Gartner, 2018).

The criteria are identified based on academic research and professional opinions of the industrial experts. The criteria are provided in Figure 3 with three main criteria and nine sub-criteria.

Figure 3: BIS Selection Criteria Hierarchy



The criteria are explained as following:

C1. Technique

The BIS implementation requires high cost and time. If the company has a better infrastructure, the set up will take less time. Moreover, if the scheduling is properly done, the set up will take less time again, and the implementation will be more efficient. Additionally, if the system is not much dependent on consultant, the maintenance of BIS will be done easily.

C2. Culture

Company culture has a crucial role on BIS implementation. Top-level support is required during the decision, set-up, implementation and utilization processes of the new BIS. The company's long term mission and vision are related to the requirements of the company, thereby, it affects the BIS selection. Moreover, the company's attitude towards the change (i.e. change culture) is another important issue.

C3. Organization

Many companies search for the most appropriate software solution according to their organizational needs. BIS provides many advantages with regard to organizational needs. For instance, top-level management wants to be continuously updated which BIS enables. BIS also provides a comprehensive approach that facilitates the understanding of the workflow and fund flow. This creates an opportunity for creating new strategies for improvement. Finally, with the utilization of BIS, the employees will realize their daily works in a more efficient way.

4. APPLICATION

There is a company XYZ that wants to implement a BIS. Different BIS alternatives exist in the market. In order to decide on the most appropriate system, XYZ decide on using scientific methods. This study aims to rank the BIS alternatives by taking experts preferences in consideration.

The criteria and sub-criteria are: C1 is technique (with Infrastructure (C11), Required time (Schedule) (C12), Dependency on Consultant (C13)); C2 is culture (with Top-Level Support (C21), Long-Term Mission and Vision (C22), Change culture (C23)) and C3 is organization (with Central Control on Workflow Data (C31), New Strategies for Improvement (C32), Efficient and Experienced Man Power (C33)).

There are four possible alternatives: A1 is Microsoft, A2 Tableau, A3 is Qlik, and A4 is Sisense. An integrated AHP-VIKOR methodology will be implemented to select the most appropriate BIS.

4.1. Criteria Weight Calculation with AHP Method

In the first stage, every criterion is compared to each other. The pairwise comparison matrix for main criteria, technique criteria, culture criteria and organization criteria are constructed. Table 3 shows the evaluation for main criteria.

Table 3: Evaluation of main criteria

	C1	C2	C3
C1	1.00	3.00	5.00

C2	0.33	1.00	3.00
C3	0.20	0.33	1.00

The associated criteria weights are calculated by utilizing Eq.(2) and Eq.(3). The consistency ratio is calculated with respect to Eq.(4). The obtained criteria weights are provided in Table 4.

Table 4: The criteria weights

Criteria	C11	C12	C13	C21	C22	C23	C31	C32	C33
Weight	0.385	0.076	0.172	0.151	0.029	0.081	0.067	0.011	0.028
Ranking	1	5	2	3	7	4	6	9	8
C.I.	0,037			0.002			0.019		

The results about weights shows that the most important criterion is Infrastructure (C11). The second criterion is Dependency on Consultant (C13) and the third is Top-Level Support (C21).

4.2. Ranking of BIS Alternatives with VIKOR Method

The method VIKOR is applied to rank the alternatives.Thus, the experts evaluated four alternatives in respect to nine criteria. Table 5 shows the evaluations for the alternatives.

The ideal f_i^* and the worst f_i^- values of all criteria functions (i=1,2,…,n) are determined according to benefit or cost functions by using Eq.(5) and Eq.(6). Here, C12 and C13 are cost function, the remaining criteria are benefit function.

Table 5: The evaluations of alternatives

	Criteria								
Alternatives	C11	C12	C13	C21	C22	C23	C31	C32	C33
A1	7	5	7	7	7	7	5	6	8
A2	5	5	5	5	4	8	8	7	6

A3	8	8	7	6	6	8	6	6	7
A4	4	4	5	8	6	7	7	5	8

The rankings BIS alternatives are calculated by using Eq.(7), Eq.(8) and Eq.(9). (v is taken as 0.5). By using Eq.(10) and Eq.(11), the values of S* = 0.423, S- = 0,0.516, R* = 0.172, R- = 0.385 are calculated. Table 6 provides the evaluation results and ranking of alternatives with respect to *Sj*, *Rj* and *Qj* values.

Table 6: The evaluations of alternatives

	Sj	Ranking	Rj	Ranking	Qj	Ranking
A1	0.491	2	0.172	1 (2)	0.368	2
A2	0.516	4	0.289	3	0.774	3
A3	0.423	1	0.172	1 (2)	0.000	1
A4	0.509	3	0.385	4	0.964	4

C1. Acceptable Advantage:

Q(A1)-Q(A3) ≥ 1/ (4-1)

0.368≥0.333

Where a''=A1 is the the second alternative in the ranking list by Q; DQ = 1/(4 -1)=0.333; 4 is the number of alternatives. Thus, the *Acceptable Advantage (C1)* is satisfactory.

C2. Acceptable Stability in Decision Making:

Alternative a' =A1 must also be the best ranked by S or/and R. Since this condition is met, this ranking result is stable within a decision making. Therefore, the results indicate that the most appropriate BIS alternative for XYZ is found as Qlik (A3).

5. Conclusion

Rapidly changing competitive business environment orients organizations to discover innovative ways by investing in novel dimensions. BIS is one of these dimensions whose utilization could create enhanced value for organizations. However, companies are compelled to select the most appropriate BIS among a variety of alternatives.

Complexity of this type of problems makes decision making even more difficult. In this study, the main purpose was to decide on the most suitable BIS alternative. This problem is solved by using the integrated AHP –VIKOR methodology. The criteria and the alternatives have been specified from a literature review, industry reports and experts review. The problem is illustrated by an application and the results are given.

This study proposes an evaluation model by providing an analytical methodology that guides researchers. Organizations that plan to implement BIS can benefit from this study. Additionally, since the proposed model is generic, it can be modified according to the requirements of the companies.
In future studies it can be interesting to use different MCDM methods on solving this problem and comparing the results. The TOPSIS method is considered to be used in lieu of VIKOR. Moreover, the number of criteria or alternatives can be different. Finally, it is possible to extend our methodology by employing fuzzy logic proposed by Zadeh, (1965).

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