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Selection of Business Intelligence System Software as Decision Support: A Case Study

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Abstract

This study focuses on Business Intelligence (BI) systems and investigates their benefits in the matter of better decision making for corporations. BI systems are computer-based decision support tools that analyse business data and generate meaningful information in order to incorporate decision making. BI systems work in parallel with existing information systems of the companies. As a matter of fact, BI systems are the next steps to be established on existing operational information systems. In this context, the purpose of this study is to examine the yield of BI systems for the companies tended to implement decision support systems aligned with their operational information systems. To investigate this phenomenon, an empirical study will be conducted among some companies in production sector in Turkey. The companies' actual implementations will be highlighted by the help of the questionnaire to be applied to those companies. Moreover, in the case study, BI system alternatives will be compared as per specifically defined criteria. In this manner, Multi criteria decision making approach will be used and Analytic Hierarchy Process (AHP) and Fuzzy AHP (FAHP) methods will be applied for the selection of the best alternative. Lastly, expected benefits and outcomes of proposed BI system will be estimated by taking into consideration of the facts and findings of the study.

Keywords: business intelligence; AHP; fuzzy AHP; decision support systems

Özet

Bu çalışma, İş Zekası (İZ) sistemlerine odaklanmakta ve şirketler için daha iyi karar verme konusunda faydalarını araştırmaktadır. İZ sistemleri, iş verilerini analiz eden ve karar vermeyi dahil etmek için anlamlı bilgiler üreten bilgisayar tabanlı karar destek araçlarıdır. İZ sistemleri, şirketlerin mevcut bilgi sistemleri ile paralel çalışır. Nitekim İZ sistemleri, mevcut operasyonel bilgi sistemleri üzerine kurulacak sonraki adımlardır. Bu bağlamda bu çalışmanın amacı, operasyonel bilgi sistemleri ile uyumlu karar destek sistemlerini uygulama eğiliminde olan şirketler için İZ sistemlerinin getirisini incelemektir. Bu olguyu araştırmak için Türkiye'de üretim sektöründe faaliyet gösteren bazı şirketler arasında ampirik bir çalışma yapılmıştır. Firmalara uygulanacak çalışma ile firmaların fiili uygulamaları ortaya konulacaktır. Ayrıca vaka çalışmasında İZ sistem alternatifleri, özel olarak tanımlanmış kriterlere göre karşılaştırılacaktır. Bu doğrultuda Çok kriterli karar verme yaklaşımı kullanılacak ve en iyi alternatifin seçimi için Analitik Hiyerarşi Prosesi (AHP) ve Bulanık AHP (BAHP) yöntemleri uygulanacaktır. Son olarak, önerilen İZ sisteminin beklenen faydaları ve sonuçları, çalışmanın gerçekleri ve bulguları dikkate alınarak tahmin edilecektir.

Anahtar Kelimeler: iş zekası; AHP; bulanık AHP; karar destek sistemleri

1. Introduction

Decision Support Systems (DSS) are computer-based information systems that provide inter-active information support to managers and business professionals during the decision-making processes. In this context, BI systems are the most well-known type of DSS systems. BI systems use analytical models, specialized databases, decision makers' own insights and judgments, and interactive computer-based modelling process to support business decisions [1]. BI systems attempt to incorporate the

knowledge of experts in various fields and suggest possible alternatives and embrace various disciplines that make up supply chain management. Accordingly, BI systems are used to address various problems, from strategic problems such as network planni ng, to tactical problems such as assignment of products to warehouses, as well as operational problems such as production scheduling and delivery mode selection. The inherent size and complexity of many of these systems make BI systems essential for effective decision making [2].

Recently, BI systems have considerable impact on corporations to consider the establishment and the use of BI tools due to the opportunities they provide. BI systems attract companies' attention since BI tools are capable to perform data mining, statistical analysis, and analytical processing of data in order to come up with better decision-making mechanism and enhanced representation of knowledge. As a matter of fact, most of the innovative companies consider making investments on BI systems. The companies are also making investigations at the outset of each BI design and implementation project to determine whether the benefits of a BI system will compensate its costs. On the other hand, success factors and performance indicators of BI systems have also been evaluated in the companies that already use BI systems. Besides, evaluations on the costs, benefits and the necessity of BI systems are always major considerations for corporations.

In this context, the main area of concern of this study is to investigate the necessity and perceived values of BI systems at the companies in production sector. In this scope, an empirical study and a survey were conducted with questionnaires applied to the companies in Ankara production sector in order to highlight the companies' perspectives on this issue and to examine their current BI system implementations. Moreover, this paper also evaluates the BI system software with a case study and selects the most applicable BI software by AHP and Fuzzy AHP Analysis for the companies in Turkey production sector. The plan of the study is as follows: After the introduction, the literature review is mentioned in the second part. The third part consists of a general discussion of the study outline and the methods used. In the fourth part, the results are analyzed. In the last part, conclusion and evaluation were made.

2. Literature Review

It is important to note that the use of information in the supply chain has also increasingly been enabled by enterprise software such as Enterprise Resource Planning (ERP) systems [3]. In addition to ERP systems, the considerable increase in the complexity of decision making and in the amount of accessible information to be concerned by managers has accelerated the development and use of decision support systems by teams of business professionals. This dramatic expansion has opened the door to use of Business Intelligence tools for decision support [4]. In this manner, BI systems can be accepted as enhancements to ERP systems. Accordingly, ERP systems and BI operations are mutually supportive. Both can exist without the other, but both can be much more profitable if used together [5].

The deluge of data has affected all organizations, and today's technology executives are feeling the pressure to help their organizations use information to work smarter. Operational systems such as ERP and front - office Customer Relationship Management (CRM) systems have been seen universally as "must haves," but for companies seeking to secure a sustainable competitive advantage in today's unforgiving marketplace, business intelligence now falls into the "must have" category as well [6].

BI helps managers by downloading information from a variety of sources for better basic leadership, traditional usage, traditional data frames, and at the same time hierarchical and functional planning, both at the traditional and strategic level; New tools are needed for job analysis [14]. There is another problem with many definitions; They tend to change in the light of the shape of what they change after a change. This is the case with BI, for example. Initially, the software business, which was busy with BI, BI, was understood as special insight, rather than state or open knowledge. Even years later, BI is still used by engineers and programmers [15]. BI is a framework that transforms knowledge into knowledge, then transforms it into learning and thus develops the company's core decision-making process [16]. BI is defined as a framework that collects, modifies, and displays information gathered from a variety of sources. BI is a system and a response that helps decision-makers understand the economic situation of

the firm [17]. BI is defined as frameworks that shorten the time needed to achieve significant business data and capture, modify, and present organizational information from a variety of sources, making it possible to use efficiency in the management decision-making process [18], allowing dynamic corporate information to be viewed, examination and clarification [17].

Business intelligence systems may be viewed as information systems with special focus on providing accessible business data, i.e., they can be viewed as type of decision support system with the capability of (easily and quickly) providing reliable and up-to-date information or key figures about the organization. Recent years have witnessed a remarkable increase of companies investing in BI systems, [19]. This makes it interesting to study the use and knowledge of the effects on the businesses of the companies utilizing, or having the ability to utilize, such systems [7]. However, the installation of such an Enterprise system is always very complex, expensive and has a massive impact on the entire organization. Due to these reasons, the installation should be evaluated carefully in order to avoid unsuccessful results in its implementation. Usually, considerations for the selection of BI systems are based on qualitative judgments and multi-criteria decisions. Therefore, the use of multi-criteria decision-making tools such as AHP and FAHP will facilitate successful results in the selection of BI systems.

3. Study Outline and Method

The study encompasses two different stages. The first stage is the survey on business intelligence applications conducted among 82 Turkish companies in Ankara production sector so as to depict the business values from BI systems, effectiveness of BI systems on decision making support, and to demonstrate the necessity for the use of BI systems. In the latter section of the paper, a case study is performed for the selection of the most suitable BI software for the companies in Ankara production sector. In the selection methodology, an analytic modelling approach such as AHP and FAHP methods have been put forward for evaluating BI software alternatives.

3.1 Survey on Business Intelligence Applications

The survey was conducted with the application of questionnaires to 82 Turkish companies from different business segments in production sector that implement BI tools for decision support. The study was carried out and the questionnaires were applied to relatively large companies that have more than 30 employees. After the application of questionnaires, the aggregated results will be presented on bar charts and the importance and value of BI systems is to be asserted.

The questions in the questionnaire consist of 6 categories. Accordingly, these categories are,

1: Visions, objectives, and strategies

2: Business values from BI systems

3: Requirements analysis and needs

4: Change Management

5: Technical Solutions

6: Decision making support

In the first category, the aim is to measure how well the currently implemented BI application suits to the company’s strategic scope and the level of contribution that BI systems make for organizational objectives and visions of the company.

The second category refers to Business values acquired from BI systems. It investigates the level of effectiveness of BI systems in supporting the company’s core business processes and meeting organizational needs.

The fourth Category reflects the effectiveness on establishing the route for organizational change and settlement of the new technology and procedures.

The Fifth Category indicates the compliance between proposed technical solutions and stipulated business objectives.

The last category, which is related to decision making support, examines the utilization of BI system in decision making and the performance of the system in supporting majority of business decisions.

Each category includes 6 questions and respondents were asked to assess these questions as per their agreement on each statement. The grades in the questionnaire were arranged on the basis of 1-to-7 Likert scale, that is, 1 refers to strongly disagreeing and 7 refers to strongly agreeing, and intermediate values refers to moderate ratings. Accordingly, the Score 4 is assumed as neutral score where it means neither agreement nor disagreement. As per the results gained from the questionnaires, the bar charts are constructed with respect to each question and the number of companies below an above the neutral score (4 out of 7) is represented. Also, average scores of the companies having assessed above 4 points and below 4 points to questions were represented in the spider diagrams to illustrate the difference between the companies that well-utilizes BI systems and the others that poorly utilizes and unaware of the outcomes of BI systems. The questionnaires were applied to companies in various industries as it is represented on the Table 1.

Table 1: The Respondent's business segments

Business Segments	**Count**
Machinery and Metal Forming	14
Electronics	13
Real Estate and Construction	12
Defence	8
Home Appliances	8
Pharmaceutical and Healthcare	7
Food and Catering	6
Energy	5
Textile	5
Others	4
TOTAL	**82**

3.2 Analytic Hierarchy Process (AHP)

The AHP enables the decision-makers to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under multiple criteria environment in confliction [20]. With AHP, the decision maker selects the alternative that best meets his decision criteria developing a numerical score to rank each decision alternative based on how well each alternative meets them. AHP approach is most useful where teams of people are working on the problems, especially those involving human perceptions and judgments [8].

In AHP, preferences between alternatives are determined by making pair-wise comparisons. In a pair-wise comparison, the decision maker examines two alternatives by considering one criterion and indicates a preference. These comparisons are made using a preference scale, which assigns numerical values to different levels of preference [21]. For instance, the scale can be 1-7 scale which lies between "equal importances" to "extreme importance". In the pair-wise comparison matrix, the value 7 indicates that one factor is extremely more important than the other, and the value 1/7 indicates that one factor is extremely less important than the other, and the value 1 indicates equal importance [22]. Therefore, if the importance of one factor with respect to a second is given, then the importance of the second factor with respect to the first will be the reciprocal [9].

- Obtaining Weights for Each Decision Criteria

Step 1: Ranking each criteria in the Pair-wise Comparison Matrix

Step 2: Normalize each column to get a new judgment matrix A' by dividing Each Value to The Column Total.

Step 3: Take average of each row of normalized matrix A' to assign the importance levels (weights of criteria) by dividing the sum of rows by the number of criteria.

- Scoring Alternatives as per Each Decision Criteria

After determination of decision criteria weights, the next step is to determine how well each alternative satisfies on the decision criteria. To make this evaluation, pair-wise comparison matrix should be constructed for each decision criteria in which rows and columns are representing the alternatives. Then, the matrix will be normalized as per each column, and next, row averages will determine the score of each alternative relative to particular decision criteria.

- Obtaining Overall Score of Each Alternative

Matrix multiplication will be performed between the ranking matrix that represents the relative scores of each alternative with respect to decision criteria and decision criteria weights matrix that indicates importance level of each criterion. Eventually, the overall scores will be obtained, and the best alternative is now ready to be selected by considering the highest overall score.

- Consistency Test of the Comparison Matrix

The additional step in AHP analysis is checking for the consistency of the decision maker's comparisons. The comparison matrix will be considered to be consistent if $CR=CI/RI<0.10$

3.3 Fuzzy Analytic Hierarchy Process (FAHP)

In most of the real-world problems, some of the decision data can be precisely assessed while others cannot. Humans are unsuccessful in making quantitative predictions, whereas they are comparatively efficient in qualitative forecasting [23]. Essentially, the uncertainty in the preference judgments give rise to uncertainty in the ranking of alternatives as well as difficulty in determining consistency of preferences [9, 24].

In complex systems, the experiences and judgments of humans are represented by linguistic and vague patterns. Therefore, a much better representation of this linguistics can be developed as quantitative data; this type of data set is then refined by the evaluation methods of fuzzy set theory. The fuzzy AHP technique can be viewed as an advanced analytical method developed from the traditional AHP. Despite the convenience of AHP in handling both quantitative and qualitative criteria of multi-criteria decision-making problems based on decision maker's judgments; fuzziness and vagueness existing in many decision-making problems may contribute to the imprecise judgments of decision makers in conventional AHP approaches [25]. So, many researchers [26 - 32] who have studied the fuzzy AHP which is the extension of Saaty's theory, have provided evidence that fuzzy AHP shows relatively more sufficient description of these kind of decision-making processes compared to the traditional AHP methods.

Fuzzy AHP also has pair wise comparison matrix like classical AHP approach. However, triangle fuzzy numbers instead of constant numbers are used to judge criteria in the comparison matrix. Accordingly, assignment of Triangular Fuzzy sets Scale are represented as follows [10],

Table 2: Triangular Fuzzy Sets Scale

Linguistic scale	Explanation	TFN	Inverse TFN
Equal Importance	Two activities contribute equally to the objective	(1, 1, 1)	(1, 1, 1)
Moderate Importance	Experience and judgment slightly favor one activity over another	(1, 3, 5)	(1/5, 1/3, 1)
Strong Importance	Experience and judgment strongly favor one activity over another	(3, 5, 7)	(1/7, 1/5, 1/3)
Very Strong Importance	An activity is favored very strongly over another, its dominance	(5, 7, 9)	(1/9, 1/7, 1/5)

According to the responses on the question form, the corresponding triangular fuzzy values for the linguistic variables are placed and for a particular level on the hierarchy the pair wise comparison matrix

is constructed. Sub totals are calculated for each row of the matrix and new *(l, m, u)* set is obtained, then in order to find the overall triangular fuzzy values for each criterion*, li/Σli, mi/Σmi, ui/Σui,(i=1,2,..., n)* values are found and used as the latest *Mi*(l_i, m_i, u_i*)* set for criterion *Mi* in the rest of the process. In the next step, membership functions are constructed for each criterion and intersections are determined by comparing each couple.

In fuzzy logic approach, for each comparison the intersection point is found, and then the membership values of the point correspond to the weight of that point. This membership value can also be defined as the degree of possibility of the value. For a particular criterion, the minimum degree of possibility of the situations, where the value is greater than the others, is also the weight of this criterion before normalization. After obtaining the weights for each criterion, they are normalized and called the final importance degrees or weights for the hierarchy level.

To apply the process depending on this hierarchy, according to the method of Chang's [33] extent analysis, each criterion is taken and extent analysis for each criterion, *gi*; is performed on, respectively. Therefore, *m extent* analysis values for each criterion can be obtained [34]. Where *gi* is the goal set (*i = 1, 2, 3, 4, 5, ...n)* and all the M_{gi}^{j} *(j = 1, 2, 3, 4, 5, ..., m)* are Triangular Fuzzy Numbers *(TFNs)*.

The basic operations to be applied throughout FAHP method. The steps of Chang's analysis can be given as follows:

Step 1: The value of fuzzy synthetic extent with respect to the i th object is defined. To obtain $\sum_{j=1}^{m} M_{gi}^{j}$ perform the fuzzy addition operation of m extent analysis values for a particular matrix and to obtain perform the fuzzy addition operation of M^{j}_{gi} (j = 1, 2..., m) values such that. Then, compute the inverse of the vector above,

Step 2: As $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two triangular fuzzy numbers, the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ can be equivalently.

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy Mi (i = 1, 2, k) numbers can be defined by

V ($M \geq M_1$,M_2 ,.....M_k) V[($M \geq M_1$) and ($M \geq M_2$) and....and ($M \geq M_k$)] = Min V($M \geq M_i$), i=1,2,3,…k

Assume that $d(A_i)$ = min V ($S_i \geq S_k$) for k = 1, 2...., n; $k \neq i$. Then the weight vector is given by where A_i= (i=1, 2...n) are n elements.

Step 4: Via normalization, the normalized weight vectors are where W is a non-fuzzy number. In Fuzzy AHP, the above procedure that consists of 4 steps should be applied for both the comparison of decision criteria and comparison of alternatives with respect to each decision criteria. Therefore, the decision maker is supposed to obtain a weight vector for decision criteria and the same number of weight vectors as the number of decision criteria indicating alternatives' scores.

Lastly, the overall scores are obtained as non-fuzzy numbers in the same way like classical AHP method by performing matrix multiplication between the ranking matrix that represents the relative scores of each alternative with respect to decision criteria and decision criteria weights matrix that indicates importance level of each criterion. Eventually, the overall scores will be obtained and the best alternative to be selected by considering the highest overall score.

In the methodology, one cannot find a consistency process for fuzzy inputs and the consistency index method is not appropriate for FAHP method because of the fuzziness. Accordingly, fuzziness concept has some bias including decision maker's inconsistency. Because of that the publications applying Chang's fuzzy AHP did not require any consistency mechanism as seen in many applications in the literature

4. Analysis And Results

The analysis and results are presented initially by considering the survey on Business Intelligence Applications over Turkish companies that make use of BI systems. In the light of the facts and findings

acquired from the survey, the study is performed by using AHP and FAHP methods in order to select the most favourable BI system software.

4.1 Analysis on the Survey on Business Intelligence Applications

The questionnaires were applied to respondents from 82 Turkish companies; the data was compiled for aggregation and graphical representation of the results.

As mentioned before, the questions were divided into 6 categories as follows,

1: Visions, objectives and strategies

2: Business values from BI systems

3: Requirements analysis and needs

4: Change Management

5: Technical Solutions

6: Decision making support

In the light of the survey, the results are presented in two formats. The first format indicates, for each category and question, the number of respondents who assessed a score of below 4 (the neutral score) and the number of respondents who assessed a score of above 4. The other format is in the form of spider diagrams showing the average score of the assessments that are below and above the neutral score for each question, i.e., the most common assessment for each question for the companies having assessed the below and above neutral scores. In this context, the difference will be observed between the companies having a good understanding and utilization of BI systems over the poor ones with respect to each category.

In the light of the evaluation constituted by 82 Turkish companies that use BI tools, Category based average scores are approximately 4.14, 4.26, 4.42, 4.38, 4.25, and 4,62 out of 7, which corresponds to the approximate overall grade of 60%, proves the agreement on BI systems' contributions to companies' Strategy, Business value and Decision-making support. Eventually, Innovative companies utilizing BI systems well; receive crucial benefits from this software in Turkey. However, it is inferred that there is no adequate awareness and vision for BI systems in small and middle-sized companies in Turkey. Therefore, they should begin to get insight about BI systems and had better use BI systems to incorporate decision making.

5. Selection of Business Intelligence Vendor

Selection of Business intelligence vendor is a critical progress. It requires comprehensive considerations and high amounts of money to design and implement the system. This paper brings a multi criteria decision making approach to select the BI vendor among possible alternatives with respect to specific criteria.

First of all, decision criteria have been determined by the discussions of companies implementing BI systems and by concerning expert judgement made by a specialist. Accordingly, the specified decision criteria with their description are given below:

- ✓ Analytical Modelling & Processing (C1): The capability of software to compile analytical processes such as analytical models, data mining and online analytical processing.
- ✓ Data Visualization & Graphical Support (C2): The ability of the software to represent information and enterprise knowledge with inter-active reporting and graphical presentations.
- ✓ User Interface (C3): The ability of the system in terms of providing a user-friendly interface and facilitating ease of use.
- ✓ Technical Guidance & Support (C4): The performance of the vendor in providing an effective consultation, trouble shooting, technical guidance and support throughout design, testing and implementation phases.

- ✓ Cost (C5): The amount of total cost of ownership which refers to investment costs in design and implementation with the addition of operational and maintenance costs throughout the lifetime of the BI system.

Secondly, the possible alternatives are to be elected for the evaluation. The 14 alternatives are determined as A, B, C, D, E, F, G, H, I, J, K, L, M and N since they are most well-known Business intelligence vendors, and it is relatively easier to compare them as there are too many experts experienced on these vendors. Besides, all software have satisfactory capabilities in terms of the decision criteria that were defined for our scope. Therefore, there will be a challenge in comparing these alternatives. As a matter of fact, the ranking and performing the pair-wise comparisons for both alternatives and for decision criteria were carried out with the expert judgment applied by specialist through considering the discussions made with Turkish companies having expertise on BI systems.

5.1 AHP Analysis

The hierarchical structure was created as a result of the data obtained. After the hierarchical structure is created, the scale is determined to compare the criteria. The binary comparison matrix is created and solved. The binary comparison matrix that created in the previous step is normalized. In the matrix obtained, relative significance weights are obtained by taking the average of each row. The consistency of the subsequent transactions is tested. In the last step, weights are determined. According to the results, software I is the alternative with the highest weight. So, software I is selected as the best BI system alternative by considering the AHP results for BI system integration to the companies operating in production sector.

Table 3. Final weights of each alternative according to AHP

Name	Criteria Weights
A	0,095432
B	0,085701
C	0,046253
D	0,051043
E	0,0959
F	0,033123
G	0,016741
H	0,102232
I	0,13209
J	0,04436
K	0,064611
L	0,096928
M	0,119611
N	0,013975

5.2 FAHP Analysis

The same procedures were made for the FAHP method. According to the results, software I is selected as the best BI system alternative by considering the FAHP results for BI system integration to the companies operating in production sector in Ankara.

Table 4. Final weights of each alternative according to FAHP

Name	Criteria Weights
A	0,18223
B	0,1623
C	0,22544
D	0,12821
E	0,15198
F	0,34646
G	0,2977
H	0,16981
I	0,66873
J	0,17561
K	0,08384
L	0,19018
M	0,3048
N	0,10738

6. Conclusion

By taking into consideration of the facts and findings of the report, this study puts an emphasis on Business intelligence systems and demonstrates real business values and the level of decision-making support acquired from BI systems. Accordingly, BI awareness and perceived values were measured by the application of questionnaires to 82 companies operating in production sector in Ankara. Consequently, it is highlighted that BI systems are beneficial tools to support decision making against business cases that enforces decision making. However, survey results indicated that BI systems are not effectively used in Ankara Production Sector in terms of enhancing company vision, business values, understanding requirements and supporting business decisions. Furthermore, a case study was conducted to evaluate BI software alternatives and to select the best alternative for the integration of BI systems to the companies attempting to insert BI systems in their decision-making mechanism. The important point is that this project brings an analytical and multi criteria decision making approach to BI system selection. Therefore, AHP and Fuzzy AHP methods were used to select the best BI software alternative. Accordingly, all software were assessed with respect to relevant criteria. Then, software I was selected as the best alternative in both methods. Hence, software I will be the most preferable option for the companies tended to implement BI systems. More to the point, the finding of the survey indicated that BI systems are effective to incorporate decision making although the use and awareness of BI systems is not satisfactory in Ankara production sector. On the other hand, managers had better perform BI system selection by means of analytical and multi criteria decision making methods such as AHP or Fuzzy AHP since BI system selection is critical for companies and involves multi criteria and conflicting objectives.

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Competing interests

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

This study does not require ethical approval.

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