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IMPROVING ERP SOFTWARE SELECTION PROCESS BY INTEGRATING QFD WITH AHP APPROACH

Methodological Article

Keywords
QFD;
AHP;
IT Support;
Decision making;
Integrated MCDM;
ERP software selection;

Abstract

Many organizations have realized the importance of establishing a reliable connection with their customers to identify their requirements, identify IT failures, answer customer queries, and provide real-time customer support in technical issues. CRM software vendors have provided various solution packages to meet companies' requirements and needs, but choosing the best one requires a full understanding of the elements involved and considering them in the decision-making process. Many decision-making approaches have been introduced to solve complicated selection problems; each method used has advantages and disadvantages. This article presents an integrated model of one of the most efficient decision-making methods, the AHP "Analytic Hierarchy Process" combined with the QFD tool. AHP has a consistency tool to measure the reliability of decisions but does not consider stakeholders' needs. In contrast, QFD does, and it provides a full overview of the technical parameters and areas for possible improvements. The integration of these two methods will eliminate the disadvantages of using each alone and create a reliable model to help in complex decisions that may define a new enterprise's success or failure.

INTRODUCTION

The ERP Enterprise Resource Planning System refers to the system and software packages used by enterprises to manage their everyday business. CRM customer relations management is an essential functional part of the ERP system. Some vendors provide CRM software only with some other functional parts of the ERP.
Selection means selecting the most suitable CRM software from among a set of vendors. MCDM (Multiple-Criteria Decision Making) is a sub-discipline of operations research. The subject of this research is those IT companies that want to adopt the ERP or CRM system with a minimum change to their already existed processes. This research has been conducted to determine which MCDM method is the best to use for ERP software selection in an IT company. By reviewing the literature of other researchers, the author has listed the advantages and disadvantages of each method used and possible improvements. The goal in this research is to create a new proposed model for solving the ERP software selection problem, which helps to make appropriate decisions to select the best software. The proposed model is a combination of QFD with AHP in the field of MCDM. This integration has not been presented before; however, it has been used in supply chain management, particularly in supplier selection. The central hypothesis is that integrating the two methods - QFD and AHP - is the best way to remove the limitations of using both methods alone in ERP software selection.

LITERATURE REVIEW

The nature of decision making

Decision making is the act of choosing one alternative from among a set of alternatives (Griffin, 2015). Managers want to make effective decisions, identify the wrong ones, and then quickly react to them. Decision-making involves identifying and clarifying the nature of a decision-making circumstance, naming alternatives, picking the best one, and putting it into practice. There are two types of decisions defined by Griffin: programmed and non-programmed.
Programmed decisions are relatively structured, or recur with some frequency (or both); these types of decisions are commonly used in warehouse restocking and ordering raw materials in operational manufacturing. On the other hand, non-programmed decisions are unstructured and occur much less often than programmed decisions. The conditions around the decision-maker are circumstances of certainty, risk, or uncertainty.
Decision Making Under Certainty: there is little vagueness and little possibility of making the wrong decision.
Decision Making Under Risk: the availability of each alternative and its potential, payoffs, and costs are all associated with probability estimates.
Decision Making Under Uncertainty: The decision-maker does not know all the alternatives or the risks and consequences associated with each alternative. To make reliable decisions in these conditions, managers must collect as much information as possible and address the situation from a logical and rational perspective.

Selection method

In order to address the Decisions Under Uncertainty category, many approaches have been proposed for information systems software selection, from basic scoring or ranking to complicated mathematical optimization and multi-criteria decision analysis. Lucas and Moore (1976) and Buss (1983) presented the scoring and ranking methods for information systems project selection. However, they were intuitive methods, and too simple to be a reliable choice for decision-makers.
Subsequently, mathematical optimization emerged, to optimize resource allocation in information systems projects using a nonlinear 0–1 goal programming model (Santhanam & Kyparisis, 1995), which considers the interdependencies among projects in the selection process of information system (IS).
Following this, Lee and Kim (2000) integrated the 0–1 goal-programming model with the analytic network process (ANP). They argued that Santhanam and Kyparisis' (1995) model had limited criteria when dealing with IS project selection issues. A further adjustment was made to the criteria for selecting an IS project by Badri, Davis and Davis (2001), who presented a 0–1 goal programming model taking into consideration multiple criteria including software and hardware, and the benefits, risk factors, and preferences of decision-makers and users, training time constraints, and completing time. However, the difficulties in dealing with the mathematical model using these previous methods are limited in a complicated practical situation, such as selecting the best ERP system to use in a company.
These methodologies focus on quantifiable calculations with limitations when it comes to considering other criteria, such as attributes that managers cannot easily quantify and understand.
Saaty (1990) introduced the AHP method, which shows how to measure the rank of a set of alternatives and determine their priority by measuring the relative importance of attributes. This method has been used in solving multiple criteria decision-making problems and been widely

adopted in different places and by many researchers.

MCDM methods

These methods have proved their efficiency in dealing with complex problems, mainly when multiple factors affect the decision. However, some problems have arisen, and researchers have started to combine methods to overcome the shortcomings of using a single specific method alone.

By reviewing the MCDM methods literature in the selection process and analysing their results, the author has identified the most suitable methods for selecting IT software, considering their advantages and disadvantages.

Velasquez and Hester (2013) listed a comprehensive review of typical applications of eleven separate MCDM methods and their corresponding strengths and weaknesses. These methods include:

1) **Multi-Attribute Utility Theory.** This shows agent preferences over a package of goods in conditions of both certainty and uncertainty about the likely choice result. It deals with uncertainty by considering risk factors and assigning a utility to every potential consequence, then calculating the best possible utility that can decide the best course of action for a given problem (Konidari & Mavrakis, 2007).

The ability to consider uncertainty and risks is an advantage of this method. On the other hand, it requires a large amount of data to obtain accurate results, and this method cannot be used when alternatives are calculated using different measurements. This method can be used whenever there is enough data with significant uncertainty, which does not apply to ERP software technical parameters.

2) **Goal Programming (GP).** This approach was first introduced in 1955 by Charnes and is famous for its ability to involve conflicting objectives and produce infinitive alternatives to handle large scale problems in production, planning, scheduling, health care, and distribution systems. The use of GP is limited and cannot be applied in the model due to its inability to weight coefficients, which is essential in the IT application selection process.

3) **The Analytic Hierarchy Process (AHP).** Proposed by Saaty (1990), this is an efficient tool used in dealing with complex decision making. It can help decision-makers prioritize criteria and make the best decision by breaking down complex decisions into smaller comparisons. Then, the results are integrated, following a hierarchical structure. (Figure 1; the goal appears at the top, while the alternative options appear at the lower level) (Wang, 2012).

The AHP includes both the subjective and objective aspects of a decision. It is easy to use, scalable, and adjustable to the size of the problem; besides, the AHP includes a valuable technique for checking the consistency of decision makers' evaluations, therefore reducing the bias within the decision-making process.

The AHP has been applied to solve performance type problems in IT software or industrial contexts. Modern supply management aims to build long term partnerships with suppliers and use fewer but reliable suppliers. Therefore, selecting the right suppliers and ranking others involves much more than considering a series of price lists. Choices will depend on a wide range of quantitative and qualitative factors, and this makes it in some ways similar to the selection and ranking of ERP systems.

Ho, Xu and Dey (2010) illustrated a review of the MCDM methods literature with a total of 78 research studies dealing with supplier evaluation and ranking collected within the period from 2000 to 2008. The aim was to find inadequacies in these methods and suggest new methods with possible future applications.

The research showed that 46 studies (58.97%) considered individual approaches, while the remainder (41.03%) dealt with integrated approaches.

The most common individual approach is Data Envelopment Analysis (DEA), followed by mathematical programming, then the AHP. DEA has only a subjective allocation of ratings for qualitative criteria. Decision-makers might become confused by the input and output criteria involved and cannot be used in The ERP software selection problem since it involves both qualitative and quantitative attributes.

Velasquez and Hester (2013) listed the disadvantages of using the AHP method alone, including the interdependence between criteria and alternatives, which can lead to inconsistencies between judgment and ranking criteria.

Among the integrated methods, the AHP integrated approaches were the most common because of their simplicity, high flexibility, and ease of use (Ho, 2008). The methods evaluated were the following:

1- Individual approaches:

a- Data Envelopment Analysis (DEA).
b- Mathematical programming: 1- Linear programming 2- Integer linear programming 3- Integer nonlinear programming 4- Goal programming 5- Multi-objective programming.
c- Analytic Hierarchy Process (AHP).
d- Case-based Reasoning (CBR).
e- Analytic Network Process (ANP).
f- Fuzzy set theory.
g- Simple Multi-attribute Rating Technique (SMART).

h- Genetic Algorithm (GA).

2- Integrated approaches:

a. Integrated AHP approaches:

- Integrated AHP and Bi-negotiation.
- Integrated AHP and DEA.
- Integrated AHP, DEA, and artificial neural network.
- Integrated AHP and GP.
- Integrated AHP and grey relational analysis.
- Integrated AHP and mixed integer nonlinear programming.
- Integrated AHP and multi-objective programming.

b. Integrated fuzzy approaches:

- Integrated fuzzy and AHP.
- Integrated fuzzy, AHP, and cluster analysis.
- Integrated fuzzy and GA.
- Integrated fuzzy and multi-objective programming.
- Integrated fuzzy and QFD.
- Integrated fuzzy and SMART.

c. Other approaches:

- Integrated ANN and CBR.
- Integrated ANN and GA.
- Integrated ANP and multi-objective programming.
- Integrated ANP and GP.
- Integrated DEA and multi-objective programming.
- Integrated DEA and SMART.
- Integrated GA and multi-objective programming.

Ho et al. (2010) concluded that even if the approaches mentioned above can deal with multiple and conflicting criteria for selecting the best supplier, the company may still not achieve what customers want without considering their stakeholders, and their business objectives and requirements and their strategic impact on the evaluation criteria.

Previous suggestions proposed by Ho et al. (2010) and (Velasquez & Hester, 2013), to overcome the disadvantages of the MCDM methods led to integrating them with other qualitative tools, such as Quality Function Development (QFD).

Xie et al. (2011) successfully tested this new QFD with an AHP approach in manufacturing, in the evaluation of suppliers' performance; QFD translated the stakeholder's needs and made them requirements that were later ranked by the AHP. However, no other model has been developed for the ERP system or CRM software selection; therefore, a generalized approach is presented in this research to integrate these two methods. The suggested approach in this article points out other possible benefits to ERP software vendors who work on improving their software and to third-party consulting companies that help organizations in transferring to a new ERP system.

AHP Analytic Hierarchy Process

The AHP was designed to deal with complex decisions by breaking them into smaller, more manageable decisions. Wei, Chien and Wang (2005) applied the AHP method in the ERP system selection process using a successful implementation and process; therefore, this research will follow a similar approach which has been developed to integrate with the QFD process, which consists of the following steps:

1. Form a team consisted of company stakeholders, then collect all possible information about ERP vendors and their technical specifications. **Input**: the Internet, magazines, exhibitions, books. **Output**: make an ERP software list.

2. Identify ERP system characteristics. **Input**: the business reason(s) for software adoption, defining problems, and methods for solving them. **Output**: make a list of the decision elements, including stakeholders' needs, the number of possible alternatives, the project's objectives, and the risks associated with the project.

3. Sketch out the problem and illustrate its possible causes.

4. Develop an initial plan which takes into consideration the possible risks and difficulties.

5. Build a structure of objectives to develop the fundamental-objective hierarchy and means-objective network.

- Create two types of objectives: the fundamental objectives hierarchy and the means objective network.
- Establish the Hierarchy of the ERP system's fundamental objectives (top-down, or bottom-up). **Input:** strategic scope. **Output**: fundamental objectives, mean objectives, and the hierarchy of objectives.

6. Extract the attributes that form the basis of the AHP for evaluating ERP systems from the structure of the objectives. **Input**: objective structure. **Output**: attributes for evaluating ERP systems (quantitative and qualitative).

7. Filter out unqualified vendors, according to system requirements. **Input:** detailed characteristics (measurable attributes). **Output**: a shortlist of ERP software candidates and a checklist (questionnaire) of system specifications.

8. Start evaluating the ERP systems using the AHP method in three phases:

1- Decomposition: the project team will develop the AHP hierarchy model from the fundamental objective.

2- Comparative judgments: each decision-maker utilizes paired comparisons for the attributes and

alternatives to extract judgment matrices with a nine-point scale at each level.
3- Synthesis of priorities: the paired comparison process is repeated for each attribute in the alternative prioritization problem. Based on the largest eigenvalue method, the relative importance of attributes and the global priority of alternatives can be obtained by aggregating the weights over the hierarchy.
9. Discuss the results and make the final decision.

Product Development Based on QFD

QFD defines customer needs compared to engineering characteristics, and assesses how relevant they are to those needs and desires.
It was established in Japan in 1966 and aims to help in transforming the voice of customers into engineering characteristics, and is commonly used for designing, developing, and improving a product.
Yoji Akao, the creator of this method, described it as a "method to transform qualitative user demands into quantitative parameters" (Akao, 1994). However, QFD is not common in other applications which require structured decisions or ranking multiple criteria, including ERP systems and CRM software selection.
Tidwell and Sutterfield (2012) proposed a five step approach to rank the supplier by applying only QFD. This research will adopt the first two steps of their approach and integrate them with the previous steps of the AHP.
Step 1. Use a cause and effect diagram (Ishikawa) to determine the customers identified and collected needs involved in the model by answering the questions "what," "where," "when," "why," and "how".
Step 2. Translate the needs collected from Step 1 into the necessary ERP software technical characteristics through the first House of Quality (HoQ) shown in Figure 2. Customer collected needs are assigned a rating in this step (using the AHP) to determine the importance of each one; then each of the ERP software characteristics is rated in terms of its effect on each of the ERP software properties.
Steps 3, 4 and 5. These steps involve rating the ERP software alternatives, and from this step, the model presented in this study will continue with the AHP to obtain the rating for the most qualified and best vendor.
Tidwell and Sutterfield (2012) concluded that their model is limited because QFD contains no tool or method for determining whether group selections have been made consistently, but this can be overcome by combining QFD with the AHP.
One of the distinct advantages of the integrating model is that stakeholders are considered by the use of QFD, which is essential for a company's strategic goals. The other advantage is having a consistent judgment for the decision-makers, thus avoiding any logical conflicts in their decisions by using the AHP instant consistency tool.

MATERIAL AND METHODS

The aim of the research is to develop existing approaches by integrating the Quality QFD with the Analytical Hierarchy Process by taking into consideration the IT support department's requirements.
A comprehensive literature review carried out by the author covers the MCDM methods used from 2000 until 2019, listing the advantages and disadvantages of using each method or integrating it with others. The suggested process is the integration of Wei's et al. (2005) AHP process with Tidwell and Sutterfield's (2012) suggested QFD method.
Figure 3 illustrates the concept of the created model, HoQ is used in QFD to list and define the customer needs from stakeholders - "the voice of the customer (VOC)" - and to identify engineering characteristics and assess how relevant they are to those needs and desires. Then, the importance and impact of each criterion are assessed using the AHP while checking the consistency of the ranking in each step. The AHP is used to break down the complex decision into smaller comparisons.
The decision-making team will collect and examine the technical parameters from multiple sources, including the vendor's websites, magazines, and internet articles. These criteria are to be collected after considering the vendors first nominated set (three to five nominees), selected on the basis of the company's structure, size, and operating sector.
Based on the stakeholders' ranked requirements and the collected ERP technical characteristics, the AHP is used again to obtain an optimal selection of the alternative ERP software packages.

RESULTS AND EVALUATION

This research proposes the following ten-step process for an AHP and QFD integrated method: start the model process by creating an initial structure, define its steps, and assess which data and criteria are missing.

Creating the Model

Figure 4 shows the process of applying the integrated model. The process starts by collecting the needs of the company and the technical parameters, using VOC and a literature review (the functional areas of ERP/CRM software and success factors that can help determine the needs and the technical parameters).

The ranking of needs comes next, using the AHP to determine which factors are the most important. Then, within the QFD table comes the relationship matrix between the needs and the technical parameters. This matrix will give the first result, which is the ranking of the technical criteria, which can help the vendors in developing the CRM product. Then, ranking the alternative options (the CRM vendors) using AHP is carried out, which will give the second result, which is the best software package, based on customer needs.

Step 1: Define the goal, problem statement, and hypothesis: The first step is to understand the existing problems in a chosen company or department and set objectives to overcome them; this is essential to provide the scope that will guide the selection process, to help to identify involved stakeholders and to validate the results.

Step 2: Collect information about MCDM methods and software success factors: It is essential to have all the required information ready before starting the implementation process; this will eliminate any unnecessary delay later on and allow the decision-making team to have a full understanding of the tools used.
The previous research literature review describes how the integrated AHP and QFD model is recommended and described the steps taken to perform each method in the selection process.
The scale in AHP rank is based on Saaty's 1-9 scale (Table 1).
Uță, Intorsureanu and Mihalca (2007) presented the criteria used to assess the different ERP systems, separating the most appropriate criteria into two groups (technical team capability and ERP software package).

Technical team capability:
- Coverage of the required functionalities/norms /regulations
- Vendor reputation and portfolio
- Guarantees offered
- Technical support quality
- Training services
- Vendor financial conditions
- Consultancy services quality
- Market share/scale of the vendor
- Implementation ability
-

ERP Software Package:
- Operating system compatibility
- Hardware requirements
- Database engine compatibility
- Integration with other platforms
- Accessibility to source code
- Documentation quality
- Software license cost
- Hardware/infrastructure cost
- Integration/middleware cost
- User-friendliness
- Maintenance cost
- Software acquisition cost (initial cost)
- Consultancy cost
- Scalability and upgradeability
- Stability and recovery capacity
- Security issues
- Customization

Some criteria can be collected from professional websites sources such as Bergen (2019) and Customer Relationship Management Software (2020), in order to select the one which relates to the selected department in an IT company.

Step 3: Form the decision-making team from the stakeholders: Form the team that will work on the model, including the collection of the requirements, ranking, and the assessment of needs and the vendors.

Step 4: Define the needs and requirements: Invite all stakeholders to provide and review department requirements. One way of collecting information and suggestions would be to create a document in a cloud drive such as Google drive, or use a special requirements management software programme.

Step 5: Define and collect technical criteria for the selected software: Understand the functionality of the software, then collect data and information about the selected vendors; these criteria will form the "How" part of the QFD Model.

Step 6: Rank the department's needs and prioritize them: The needs are ranked according to their importance using the MCDM AHP. $\boldsymbol{w}$ is calculated (i.e. an m-dimensional column vector) by averaging the entries on each row of the Standardized Matrix.

Step 7: Measure the consistency of the weighted department needs: The consistency of the ranking shows how accurately the decision-makers have determined the ranking:

$$CI = \frac{X - m}{m - 1}$$

m = the number of examined criteria.
The scalar X is the average of the weighted needs divided by m.

$$x = \frac{\sum weighted\ needs}{m}$$

Using programmed software or a customized Excel spreadsheet using the matrix multiplication function MMULT() to measure the consistency, the decision-maker can see it directly and adjust his/her decisions to make them more consistent; decisions are perfect when CI=0, but other values up to 0.2 can be accepted depending on the number of ranking criteria and alternatives. The Random Index (RI) values are given from Saaty's CIr values for matrices (Saaty, 2008).

Step 8: Fill out the Relationship matrix: Perform the relationship matrix between the defined requirements and the technical parameters within the QFD matrix. This provides the first results for the proposed model by ranking the technical criteria to define which technical parameters are the most important ones that can help vendors develop their software.

Step 9: Rank the alternative using AHP: The aim is to rank the competitors' software and select the best choice for the company based on their needs. Using the final obtained matrix, i.e. the 'score matrix (S)'. Each alternative's rank is calculated by the following formula:

$$v = S.w$$

$\boldsymbol{w}$ is the weight vector of the needs
S is the calculated score matrix

Step 10: Communicate the results:
By reviewing the literature from other researchers, the advantages and disadvantages of each method used and possible improvements can be assessed. In conclusion, Based on Xie et al. (2011), Ho et al. (2010) and (Velasquez & Hester, 2013), the AHP with QFD integrated model is the best MCDM method for the selection of ERP Software in the IT industry.
After filling the base structure of the model, the AHP is used to break down the complex decision into smaller comparisons, and the team starts the process by ranking the needs, and then the alternatives with consideration given to the ranked needs.

CONCLUSIONS

This study aimed to propose a new integrated methodologically appropriate model to help decision-makers solve complex problems by combining the AHP with the QFD method in the field of MCDM. The formulated hypothesis was proven to be true based on the literature review in this article. After scanning many articles that mentioned the limitations of using MCDM methods, QFD and the AHP proved their efficiency, except for the disadvantages involved when using each method alone.
Considering that stakeholders are essential for companies' strategic goals, the AHP does not consider these goals, while QFD does. QFD provides a full overview of the technical parameters and areas which need improvement but does not have a consistent tool to measure the reliability of decisions made by decision-makers. The AHP consistency tool is used to avoid any logical conflicts in their decisions, allowing them to reconsider their rank to reach a consistent judgment at the end.
This research has two valuable outcomes; the first is that it creates a model specialized in ERP software; it can be generalized to become a decision-making software programme or a website which provides this service. The second is that it features an integrated model that helps companies select the best software that meets their needs. It would be fruitful to pursue further research in a real case study to verify the efficiency of this integrated model.
It has always been difficult to make decisions when there are many criteria involved, especially when it comes to essential, but sophisticated, software that defines the company service and is the initial interface that deals with customers.
This study offers a comprehensive, integrated approach that considers technical requirements and stakeholders' requirements. Creating this integrated model overcomes existing disadvantages and provides a solution that can deal with complex problems.

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Biographical Sketch
Hasan is a highly motivated Industrial Engineer who graduated as the top student in his class, then continued his education in Hungary and obtained an MSc in Engineering Management. He was able to obtain practical work experience in international companies during his studies, which provided him with strong managerial and problem-solving skills. Currently, he is focusing on IT Management. His PhD is about the implementation of agile and lean management in IT companies.

REFERENCES

[1] Akao, Y. (1994). Development history of quality function deployment. *The Customer*

Driven Approach to Quality Planning and Deployment, *339*, 90.

[2] Badri, M. A., Davis, D., & Davis, D. (2001). A comprehensive 0–1 goal programming model for project selection. *International Journal of Project Management*, *19*(4), 243-252. doi : 10.1016/S0263-7863(99)00078-2

[3] Bergen, Adair (2019). Top CRM Features and Functionality List. *Select Hub*. retrieved from https://www.selecthub.com/customer-relationship-management/crm-features-functionality-list/

[4] Buss, M. D. (1983). How to rank computer projects. *Harvard business review*, *61*(1), 118-125.

[5] Customer Relationship Management Software. (2020). *capterra*. retrieved from https://www.capterra.com/customer-relationship-management-software/

[6] Griffin, R. W. (2015). Fundamentals of management. (8th ed.). *Cengage Learning.*

[7] Ho, W., Xu, X., & Dey, P. K. (2010). Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. *European Journal of operational research*, *202*(1), 16-24. doi : 10.1016/j.ejor.2009.05.009

[8] Ho, W. (2008). Integrated analytic hierarchy process and its applications–A literature review. *European Journal of operational research*, *186*(1), 211-228. doi : 10.1016/j.ejor.2007.01.004

[9] Konidari, P., & Mavrakis, D. (2007). A multi-criteria evaluation method for climate change mitigation policy instruments. *Energy Policy*, *35*(12), 6235-6257. doi : 10.1016/j.enpol.2007.07.007.

[10] Lee, J. W., & Kim, S. H. (2000). Using analytic network process and goal programming for interdependent information system project selection. *Computers & Operations Research*, *27*(4), 367-382. doi : 10.1016/S0305-0548(99)00057-X

[11] Lucas, H., & Moore, J. (1976). A multiple-criterion scoring approach to information system project selection. *INFOR: Information Systems and Operational Research*, *14*(1), 1-12. doi : 10.1080/03155986.1976.11731622

[12] Quality Function Deployment (QFD). (2020). *Quality-One International*. retrieved from https://quality-one.com/qfd/

[13] Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International journal of services sciences*, *1*(1), 83-98. doi : 10.1504/IJSSci.2008.01759

[14] Saaty, T. L. (1990). How to make a decision: the analytic hierarchy process. *European journal of operational research*, *48*(1), 9-26. doi : 10.1016/0377-2217(90)90057-I

[15] Santhanam, R., & Kyparisis, J. (1995). A multiple criteria decision model for information system project selection. *Computers & Operations Research*, *22*(8), 807-818. doi : 10.1016/0305-0548(94)00069-K doi : 10.1108/02656711211216144

[16] Tidwell, A., & Sutterfield, J. S. (2012). Supplier selection using QFD: a consumer products case study. *International Journal of Quality & Reliability Management*.

[17] Uță, A., Intorsureanu, I., & Mihalca, R. (2007). Criteria for the selection of ERP software. *Bucharest: Academy of Economic Studies*, *0(2)*, *63-66*.

[18] Velasquez, M., & Hester, P. T. (2013). An analysis of multi-criteria decision making methods. *International journal of operations research*, *10*(2), 56-66.

[19] Wang, T. C. (2012). The interactive trade decision-making research: An application case of novel hybrid MCDM model. *Economic Modelling*, *29*(3), 926-935. doi : 10.1016/j.econmod.2012.02.001

[20] Wei, C. C., Chien, C. F., & Wang, M. J. J. (2005). An AHP-based approach to ERP system selection. *International journal of production economics*, *96*(1), 47-62. doi : 10.1016/j.ijpe.2004.03.004

[21] Xie, C., Anumba, C. J., Lee, T. R., Ho, W., Dey, P. K., & Lockström, M. (2011). Strategic sourcing: a combined QFD and AHP approach in manufacturing. *Supply Chain Management*, Vol. 16 No. 6, pp. 446-461. doi : 10.1108/13598541111171093

LIST OF TABLES

Table 1
The fundamental scale of absolute numbers

Intensity of Importance	Definition	Explanation
1	Equal importance	Two criteria contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment slightly favor one criterion over the other
5	Essential or strongly important	Experience and judgment strongly favor one criterion over the other
7	Very strong or demonstrated importance	Experience and judgment very strongly favor one criterion over the other; its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one criterion over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

Source: (Saaty, 2008)

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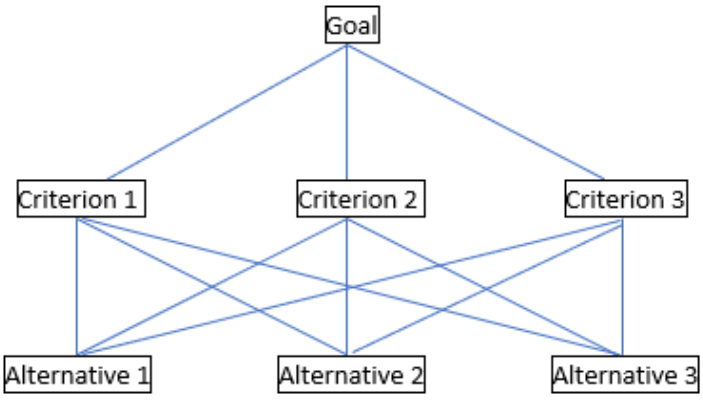

Figure No. 1
AHP hierarchical structure model
Source: (Saaty, 1990)

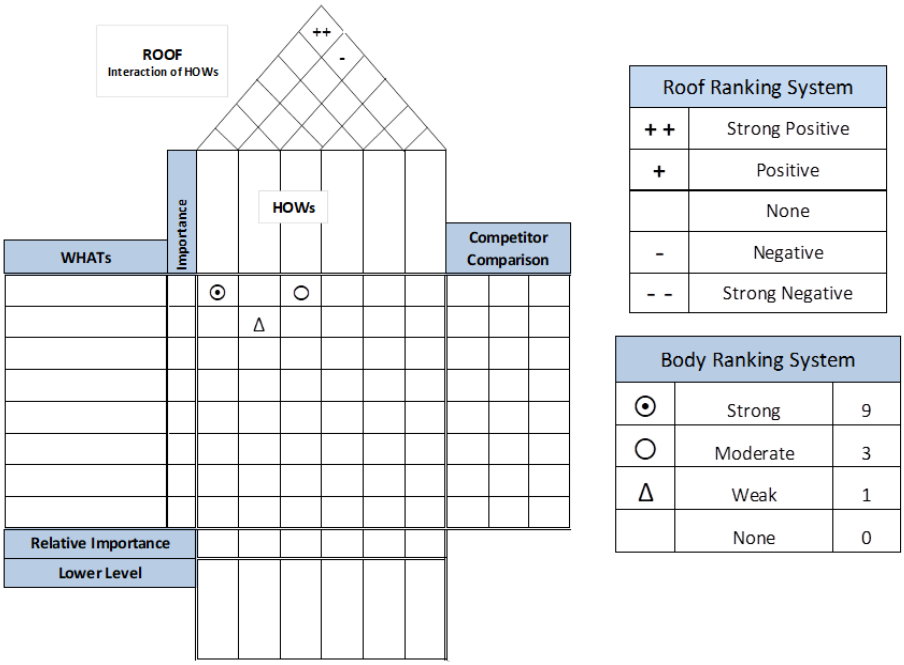

Figure No. 2
QFD house of quality (HoQ)
Source: ("Quality Function Deployment (QFD)," 2020)

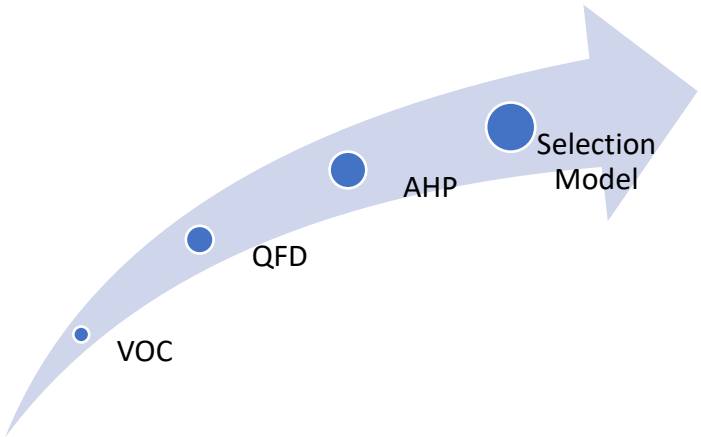

Figure 3
Diagram shows the concept of the integrated model
Created by the author

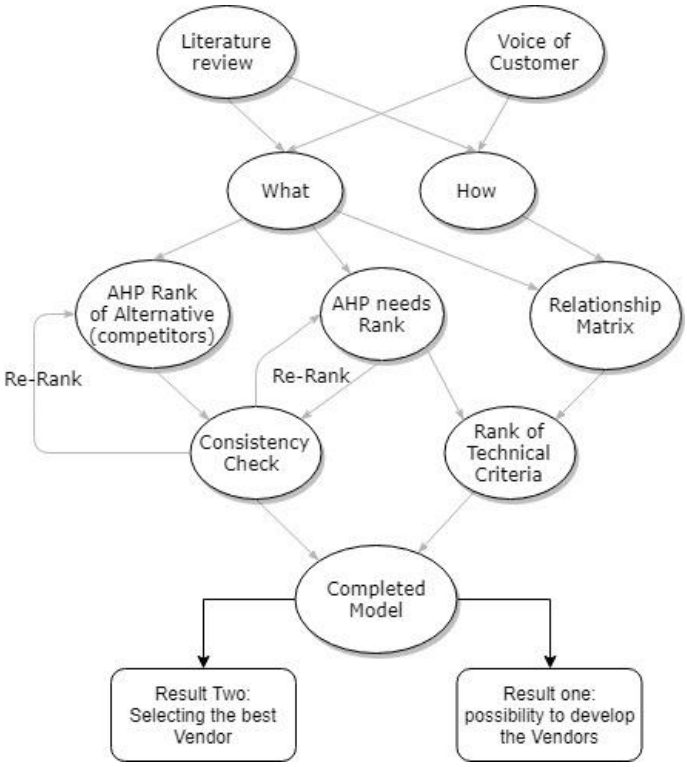

Figure 4
The process of applying the Integrated QFD and AHP model
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