Evaluating and Selecting E-markets in E-Business Using MultiCriteria Analysis

Abstract—This paper presents a multicriteria analysis approach for evaluating and selecting e-markets in conducting organizational business-to-business e-business. The multi-dimensional nature of the evaluation and selection process for choosing the most appropriate e-market in developing organizational business-to-business e-business is handled in the context of multicriteria analysis, the subjective ness and imprecision of the human evaluation process is modeled with the use of pair wise comparison represented by linguistic variables approximated by triangular fuzzy numbers. An efficient algorithm is developed for producing a success index for every alternative e-market across all selection criteria, on which the selection decision can be made. An example is presented for demonstrating the applicability of the proposed multicriteria analysis approach for solving the problem of selecting the most appropriate e-market in a specific situation in order to develop a successful business-to-business e-business in an organization.

Index Terms—Multicriteria Analysis's-market; Business-to-Business E-Business; Fuzzy Sets

I. Introduction

Electric markets (e-markets) are a virtual market place where buyers and sellers are brought together in one central market for exchanging goods, services or information. They are often referred to as a website that allows businesses to buy and sell industrial products and services using a standard web browser, commonly referred to as

business-to-business e-business. E-markets have been established on the Internet since the middle of 1999 [2, 17, 1920, 27, 29]. They are enabled and facilitated by the advances of information and communication technology, especially web technology.

E-markets have been increasingly popular in the recent decade. Evidence of this phenomenon cannot only be found in the rapid growth of e-market product and service offerings, but also in the wealth of literature resulting from the active research in this area [8, 20, 22, 28, 44]. A simple online search shows that there are 656 e-markets listed in the directory on the website of e-market services, spanning across different industries and geographical regions [18, 38].

The popularity of e-markets in e-business is due to their potential benefits to organizations including strengthened customer relationships, ease of reaching the targeted market, improved efficiency and reduced costs and greater competitive advantage [10, 37, 38, 44]. Through e-markets, organizations can achieve market efficiency by tightening and automating the relationship between supplier and buyer. With the use of e-markets, the exchange of information, goods and services can be fostered and facilitated in all transactions regardless of their locations. In such transaction processes, e-markets create the economic value for buyers, sellers, and market intermediaries, leading to lower search costs, reduced transaction costs, wider accessibility of a large base of buyers or suppliers, improved flexibility, business processes automation, improvement in service quality, and reduction of inventory cost [27, 36, 37].

The potential benefits of e-markets, however, do not guarantee the success of participating into e-markets in organizations for e-business. The new millennium, in fact, has witnessed the rise and the fall of many 'dot.com" organizations [31, 33]. As a consequence, both the companies and the investors are extremely cautious about the performance and effectiveness of e-marketplaces while planning for their e-business ventures. To organizations ready for participating in e-markets for their e-business, the evaluation and selection of a specific e-market for conducting their e-business successfully would be of critical

importance in today's dynamic environment [4, 5, 9].

A literature review on the evaluation and selection of e-markets for e-business shows that there are only a few developments on the approaches available for assisting with the evaluation and selection of e-markets in e-business. For example, Buyukozkan [4, 5] presents a fuzzy analytic hierarchical process (AHP) approach for addressing the e-market evaluation and selection problem in the context of multicriteria analysis. Hopkins and Kehoe [21] develop a matrix-based approach for facilitating the evaluation and selection of e-markets. Das and Buddress [9] use an empirical study to identify the criteria and subsequently assess their relative importance using statistical analysis for the evaluation and selection of e-markets. These approaches are developed for facilitating the e-market evaluation and selection and providing the decision maker with vital information for making informed e-business decisions. They are however not totally satisfactory due to several shortcomings including (a) the inadequacy of handling the subjectiveness and imprecision in the human decision making process, (b) the cognitive demanding nature of the approach on the decision maker, and (c) the sophisticated computation effort required. It is desirable to develop an effective approach for solving the e-market evaluation and selection problem capable of addressing the shortcomings as above.

This paper presents a multicriteria analysis approach for evaluating and selecting e-markets to help organizations in their pursuit of e-business. The multi-dimensional nature of the evaluation and selection process for choosing the most appropriate e-market is handled in the context of multicriteria analysis, the subjectiveness and imprecision of the human selection and evaluation process is modeled with the use of pairwise comparison represented by linguistic variables approximated by fuzzy numbers. An efficient algorithm is developed for producing a success index for every alternative e-market across all criteria and their associated sub-criteria in a given specific situation, on which the selection decision can be made. An example is presented for demonstrating the applicability of the proposed multicriteria analysis approach for solving the problem of selecting the most appropriate e-market in a specific situation in order to develop a successful e-business in an organization.

In what follows, we first present an overview of e-market. We then formulate the process of evaluating and selecting e-markets as a multicriteria analysis problem and present a multicriteria analysis approach for solving the e-market evaluation and selection problem. We finally present an example for demonstrated the applicability of the proposed approach for assisting with the evaluation and selection of e-markets in a specific situation.

II. An overview of e-market

E-markets are developed to bring multiple buyers and sellers together in one virtual place for facilitating the trading between them, although e-markets emerge in different industries, supporting the exchange of goods and services of different kinds, with and for different types of actors, and are following different architectural principles [2, 20, 26, 27, 45]. To support the core function of e-markets, e-markets provide different kinds of services including (a) managing buyers' and sellers' offers and bids, (b) matching and linking sellers to buyers, and (c) exchanging information about prices and product offerings between potential buyers and sellers.

Over the development of e-markets in the past decade, many terms and definitions have been used to describe e-markets. Various terms such as e-marketplaces, e-hubs, exchanges, auctions, and portals seem to overlap. These terms often mean different things to different people [20, 27]. For example, Grieger [20] defines e-market as a marketplace that brings buyers and sellers together in one central market space and implicitly involves trade financing organizations, logistics companies, taxation authorities and regulators. Bakos [1] considers e-market as an inter-organizational information system that allows the participating buyers and sellers in some markets to exchange information about prices and

products offerings. Nairn [29] describes e-market as a website that allows business to buy and sell industrial products and services using a standard web browser. Soh et al [35] (2006) view e-markets as IT-enabled intermediaries that connect many buying organizations with many selling organizations. For simplicity, this study treats e-market as a neutral web-based location where businesses can conduct buying and selling transactions for goods and services in such a virtual marketplace [30].

There are various classifications on e-market for better understanding the characteristics of e-markets from different perspectives [20, 36, 44]. Based on the organization that operates the e-market, e-markets can be classified into private e-markets and non-private e-markets [28, 36]. In regard to the industries served, e-markets are often classified as vertical e-markets and horizontal e-markets. With respect to the focus of stakeholders, e-markets can be divided into buyer-oriented e-markets, seller-oriented e-markets, and the third party e-markets [2, 20]. The buyer-oriented e-market aims to drive procurement costs down for the participating buyers, to allow buyers to "aggregate their expenditure", to reduce administration costs, to increase visibility and to facilitate global sourcing. The seller-oriented e-market concentrates on bringing multiple sellers together into a central catalogue and product information repository for the same purpose. Neutral e-markets, commonly referred to the third-party e-markets, focus on both sellers and buyers which is the most commonly available e-markets for organizations to conduct business-to-business e-business. To be successful in e-business, evaluating and selecting the most appropriate e-market is of critical importance for modern organizations.

The neutral e-markets are true market makers because they represent a relatively neutral position between buyers and sellers. These e-markets provide services to both sides of transactions and take into account the interests of both buyers and sellers in their governance [27]. The neutral e-markets referred to as e-markets from now on are viewed as the future of business-to-business e-business. For example, Timmers [39] views e-business in terms of the level of functional integration and the degree of innovation where an enterprise has a business model that is determined by its rating based on these two parameters. E-markets are placed in the upper right quadrant as they provide multiple functions and require higher level of innovation. E-markets avoid the dominance of the powerful players in the marketplace and are characterized with their independence and neutrality.

The failure of some early efforts to create private e-markets as well as the huge success of neutral e-markets has led to the increasing interest by the companies looking at joining such e-markets for their organizational business-to-business e-business [10]. Some e-markets are floundering and are adorned with their enormous number of users or members, their huge product list, the number of offers to sell or requests to buy that are placed on their website each day; or the quantities that have been traded. The number of completed transactions, however, is much smaller than the number of members. This may be due to the critical problems existent in some e-markets including (a) the proper definition of the value proposition, (b) the effective realization of the potential benefit of e-markets, and (c) the adequacy of the business models for e-markets [46].

The continuous popularity of e-markets offer unprecedented opportunities and risk for companies who participate in such e-markets [23, 31]. To ensure that organizations can successfully conduct their business-to-business e-business, organizations have to comprehensively evaluate and select the most appropriate e-market with respect to the requirements of individual organizations [9, 30]. Such an evaluation and selection process has to consider both the multi-dimensional nature of e-market selection process and the presence of subjective ness and imprecision in the decision making process which is the focus of the discussion in the next section.

III. Multicriteria analysis for evaluating and selecting e-markets

The multi-dimensional nature of the process for evaluating and selecting the most appropriate e-markets in a specific situation [4, 5; 19, 28], the presence of subjective ness and imprecision in the human decision making process [5], and the need for conducting a comprehensive evaluation on all alternative e-markets in a timely manner justify the use of multicriteria analysis approaches for solving the problem of the e-market evaluation and selection in e-business.

There are numerous discussions on the criteria and sub-criteria, which can be used for evaluating and selecting e-markets in conducting organizational business-to-business e-business. For example, Doherty and McAulay (2002) present a provisional framework for the evaluation of investments in sell-side e-commerce. A number of criteria have been identified in the study including the suitability of products, the competitive environment, the links to corporate strategy, the customer relationships, the e-market value proposition, the /brand management, the marketing strategy, the system interfaces, the e-market security, the logistics processes, the e-market implement-ability, the risk, the flexibility, the links to strategy, and the development of business model. Hopkins and Kehoe [21, 22] develop an interrelationship matrix-based method for evaluating and rating the appropriateness of a range of services offered by e-markets in comparison with specific customer requirements. The matrix emphasizes the interrelationship between their customer requirements and e-market functionality. Customer requirements include procurement savings, reduced administrative costs, order status/tracking, product search, vendor search, and integration with existing systems, integration to other exchanges, collaborative planning, and supplier price comparisons. E-market functionality features include electronic requisitions, electronic purchase orders, electronic delivery notes, electronic catalogues, contracted pricing displayed, user profiles with spend limits, automated approval process, order tracking and audit trail, management information and reporting, online reverse auctioning, integration with back office systems, automated payment, and online asset management. Sharifi et al. [34] provide a framework for the classification and selection of e-markets. Three dimensions are considered in the framework including ownership and structure, products and services, and functionality.

A comprehensive literature review on the criteria and their associated sub-criteria for the evaluation and selection of e-markets shows that there are main four criteria including (a) Market Performance, (b) Economic value, (c) Process Capability, and (d) E-business Maturity which are critical for the selection of the most appropriate e-market for conducting organizational e-business in a specific situation. Table 1 shows an overview of all the criteria and their associated sub-criteria for the evaluation and selection of the most appropriate e-markets for organizations in e-business.

TABLE I AN OVERVIEW OF CRITERIA AND SUB-CRITERIA FOR E-MARKET EVALUATION AND SELECTION

Criteria	Sub-Criteria
Performance (C_1)	Strategic Fit (C_{11})
	Market Orientation (C_{12})
	Market Accessibility (C_{13})
	Market Attractiveness (C_{14})
Economical Value (C_2)	Market Volume and Liquidity (C_{21})
	Market Fragmentation (C_{22})
	Market Revenue Model (C_{23})
Market Process Capability (C_3)	Market Process Characteristics (C_{31})
	Management Support (C_{32})
	Technological Competence (C_{33})
Industry E-Business Maturity (C_4)	Industry Characteristics (C_{41})
	E-Business Readiness (C_{42})

The performance of e-markets is critical to every organization aiming to participate in e-markets for conduct their organizational e-business [8, 28, 37]. This performance although often subjective and different to different organizations with the presence of different decision makers can usually be measured by several sub-criteria including the strategic fit, the market orientation, the market accessibility, and the market attractiveness [6, 9]. The success or failure of an e-business based on the participation into e-market by an individual organization obviously depends on the adequate matching between the objectives of an organization and the overall intention of the e-market involved [5, 31] which is measured by the e-market performance criterion.

The strategic fit of an e-business venture with the characteristics of e-market is determined by the degree of matching between the objectives of an organization in conducting e-business and the overall intention of an e-market for delivering its products and services. To adequately determine that, the decision maker often requires to identify specific strategic needs that e-business application can satisfy and confirm compatibility and support from the e-provider in those goals. The key issue here is that organizations need to determine what is really needed for successfully conducting their e-business and what an e-market can offer. As a result, any redundancies in the e-market software can be removed.

The market orientation relates to the determination of the market with the identification of specific buyers and sellers and the products available in that specific market [31]. This is more to do with the market segmentation from a business perspective [2] and the nature of the business that the e-business venture is to pursue. Depending on the perspective of individual organizations, the market orientation may be different in relation to the nature of the product and service and the strategic objectives of the organization.

The market accessibility concerns about the industry knowledge, market expertise and product and service determination at the right time for creating a powerful value proposition towards it target markets. Obviously the continuously increasing product complexity makes market knowledge and product expertise the critical elements of a winning strategy in many industries. The wishes and needs of the customers can be changed according to the time, region, and the sector. To improve the overall performance of e-market, the products and services offered in the e-markets should be more effective, more developed, and more specialized. To achieve this, a personalized e-market that has the industry know-how, e-commerce know-how, and conceptual know-how is clearly desirable.

The market attractiveness refers to the power of presented services, created values and the relationships [27]. This is often determined based on the historical performance of the e-market and the uniqueness of the market in a specific situation [2, 3]. Without any unique differences between two e-markets, individual organizations then have no difficulties to switch from one e-market to another. As a consequence, evaluating and selecting the most appropriate e-market for conducting organizational e-business is no longer an issue.

The aim of the marketplace is to create values for all participants [3, 37]. The economic value of e-market is the fundamental drive for organizations to conduct business-to-business e-business nowadays due to the tremendous benefits that e-market can bring to organizations. A review of relevant literature shows that the economic value of e-markets is determined by the market liquidity, market fragmentation, and market revenue model [5, 6, 9].

The market liquidity is a critical indicator for the potential success of an e-business venture with the involvement of e-market that is determined by the volume of the e-market. The higher the volume of transaction of the e-market is, the higher the likelihood of success the e-business venture is. It is well recognized that the market liquidity can be transformed into market dominance. This in turn can be translated into the economies of scale and scope which are the fundamental drivers of the e-market business models. To achieve high market liquidity, the provider of e-markets has to carefully consider the purchasing power of potential customers, the coverage of e-market, and the technological sophistication.

The market fragmentation refers to the degree of dispersion of buyers and sellers in a specific market and industry [17]. It is well known that fragmented buyers and sellers, the difficulties of bring them together, high vendor and product search/comparison costs, and a strong willingness to cut expense are the underlying drivers for the participation into e-markets by individual e-markets.

The e-market revenue model is related to the value proposition that an e-business uses to appeal to its targeted customers. It is clear that the biggest challenge for every e-market is what the e-market can do to charge its customers for the value that it provides. Although there are various kinds of e-market revenue models such as buyers and seller transaction fees, buyers and sellers subscription fees, license fees, the success of a specific revenue model is very much dependent on an understanding of the potential customers [3] and the competition that may come from [27, 34].

The e-market process capability concerns about the efficiency and effectiveness of e-markets for delivering the products and services that they offer [3, 4, 37]. This includes process characteristics, management involvement, and technological competency. The e-process characteristics include e-transformation degree, the scope of e-process, the transaction path, and the nature of the supply chain that is involved. Obviously an e-market can be more preferable if there are more interactions and cooperation between partners in the supply chain.
The importance of management team and its approach to e-market for the e-transformation of all transactions is a critical factor for determining the e-market capability in conducting e-business. It is recognized that it is the human factor that determines realizes and leads the perfect strategy to success in e-business. As a consequence, it is vital to have a good management structure that provides the rules for the efficient exchanges of goods and services with minimized conflicts in a fully supported decision making environment.

The level of technological competency refers to the development of the right technological platform in a specific market [22]. A competent technological platform should be able to equip with e-market with the advanced marketing making tools, integrated procurement tools, and advanced collaboration tools. A competent e-market should be robust, scalable, flexible, easy to use, reliable, and of course secure.

Industry e-business maturity describes the level of development in e-business in a specific industry [6, 37]. The level of e-business maturity has a significant impact on the way that e-business should be carried out in that specific industry. Several sub-criteria are to be considered including the characteristics of the industry involved, the e-business readiness of the industry, and the e-implement ability.

The characteristics of industry are used to describe the relationships between the targeted groups of the e-market and the e-business. It is often concerned about the degree of integration among the banking, commercial, and accounting systems, which are the foundation of a smoothly functioning supply chain. The electronic network infrastructure is expensive although they can be used to make the business transactions efficient and effective in a specific industry. As a result, every individual organization has to carefully consider the size of the e-market, the buyer and seller fragmentation, the degree of adoption of the technology in that industry in their evaluation and selection of a specific e-market.

The e-readiness of the industry refers to the external conditions that influence an e-market success. Those external conditions include political, cultural, economical and other environmental factor specific to individual countries and regions. It is clear that all those conditions would directly affect the adoption of the technologies in e-markets and the development of infrastructure for successfully conducting organizational business-to-business e-business. To some industries, there is more support for e-market success because of their product fit and industry readiness for e-business [6].

The e-implement ability of e-market is related to the functionality of e-market in a specific situation for conducting e-business. As we know it is rare to find a perfect functionality of an e-market with respect to the expectation and requirement of an organization for conducting e-business. From an organizational perspective, it is desirable to find an e-market that can match its characteristics in terms of its functionality with the organizational culture, existing business processes, legal

systems, user skills, and data protocols of external members of the supply chain. Also it is important to consider other factors such as the training time and systems roll-out time before choosing an e-market for e-business.

IV. MULTICRITERIA ANALYSIS APPROACH

Effectively and efficiently evaluating and selecting e-markets in e-business requires the development of a multicriteria analysis approach [3, 4, 5]. The approach developed must be capable of addressing the shortcomings of existing multicriteria analysis approaches including (a) the inappropriateness of handling uncertainty and imprecision of the decision making process, (b) the cognitive demanding on the decision maker in making subjective assessments, and (c) the complex and unreliable process of comparing fuzzy utilities [11, 12, 40]. To this end, this section presents a multicriteria analysis approach for effectively solving the problem of evaluating and selecting e-markets in e-business.

Evaluating and selecting e-markets usually involves in (a) discovering all the alternative e-market denoted as A_i (i = 1, 2, …, n), (b) identifying the selection criteria, C_j (j = 1, 2, …,m) and their associated sub-criteria C_{jk}(k = 1, 2, …, P_j) *(c)* assessing the performance ratings of the alternative e-markets X_{ij} (i = 1, 2, …, n, j = 1, 2, …, m) or $y_{ik}$with respect to each criterion or sub-criertion, and the relative importance of the selection criteria, W_j (j = 1, 2, …, m) or sub-criteria as W_{jk}, (d) aggregating the alternative ratings and criteria weights for producing an overall success index for alternative e-markets across all criteria, and (e) selecting the most appropriate e-market based on the success index values.

Mathematically, the e-market evaluation and selection problem can be formulated as follows:

Max fi (u), i = 1, 2, …, k,
Subject to: gj(u) ≤ 0, j = 1, 2, …, n,

where u is a m dimensional decision variable vector. Specifically, the evaluation and selection process starts with the determination of the performance of alternative e-markets with respect to each criterion and the relative importance of the selection criteria and their associated sub-criteria [13]. To greatly reduce the cognitive demanding on the decision maker in the decision making process, pairwise comparison technique commonly used in the AHP [32] is applied. To facilitate the making of subjective pairwise assessments in the human decision making process, linguistic variables approximated by fuzzy numbers are used [11, 12, 14, 43]. Table II shows the linguistic variables and their approximations using triangular fuzzy numbers for representing pairwise comparison assessments.

TABLE II. LINGUISTIC VARIABLES AND THEIR APPROXIMATIONS USING TRIANGULAR FUZZY NUMBERS

Linguistic Variables	Fuzzy Numbers	Membership Functions
Equal Importance	$\tilde{1}$	(1, 1, 3)
Moderate Importance	$\tilde{3}$	(1, 3, 5)
Strong Importance	$\tilde{5}$	(3, 5, 7)
Very Strong Importance	$\tilde{7}$	(5, 7, 9)
Extreme Importance	$\tilde{9}$	(7, 9, 9)

Using the linguistic variables described as in Table I, a pair wise judgment matrix can be obtained for alternative
performance or criteria importance respectively as in (1) where $k = n$ or m and $a_{12} = a_{21}$.

$$A = \begin{bmatrix} 1 & a_{12} & - & a_{1k} \\ a_{21} & 1 & - & a_{2k} \\ - & - & - & - \\ a_{k1} & a_{k2} & - & 1 \end{bmatrix} \quad \text{---------- 1}$$

Using the fuzzy synthetic extent analysis as described in Deng [12], the criteria weights (w_j) and the performance rating (x_{ij}) with respect to criterion C_j can be obtained, resulting in the determination of the fuzzy decision matrix for the alternative e-markets in (2) and the fuzzy weighting vector for the selection criteria in (3) as follows:

$$X = \begin{bmatrix} x_{11} & x_{12} & - & x_{1m} \\ x_{21} & x_{22} & - & x_{2m} \\ - & - & - & - \\ x_{n1} & x_{n2} & - & x_{nm} \end{bmatrix} \quad \text{---------- 2}$$

$W = (W_1, W_2, \ldots\ldots\ldots, W_m)$ ----------3

If sub-criteria C_{jk} (k = 1, 2, …, p_j) are existent for criterion Cj, a lower-level decision matrix can be determined for all the alternative e-markets based on the (1) using fuzzy synthetic extent analysis, given as in (4) where y_{ik} Bare performance ratings of alternative A with respect to sub-criteria Cjk (j = 1, 2, …, m; k = 1, 2, …,Pj) of the criterion Cj (j = *1, 2, …, m*).

$$Y_{cj} = \begin{bmatrix} Y_{11} & Y_{12} & - & Y_{n1} \\ Y_{12} & Y_{22} & - & Y_{n2} \\ - & - & - & - \\ Y_{1pj} & Y_{2pj} & - & Y_{npj} \end{bmatrix} \quad \text{---------- 4}$$

Following the same token, the weightings for the sub-criteria can be determined as in

$$W_j = \left(w_{j1}, w_{j2}, w_{j3}, \ldots\ldots\ldots, w_{jk}, \ldots\ldots\ldots w_{jp_j}\right)$$

----------5

With the determination of the lower level decision matrix for criterion C_j in (4) and the weighting vector in (5) for its associated sub-criteria C_{jk} (k = 1, 2, …, P_j), the decision vector $(X_{1j}, X_{2j}, \ldots\ldots\ldots, X_{nj})$ (the alternatives with respect to criteria C_jB$_B$in (1) can be determined by

$$\left(x_{1j}, x_{2j}, \ldots\ldots\ldots, x_{nj}\right) = \frac{W_j Y_{cj}}{\sum_{k=1}^{p_j} W_{jk}} \quad \text{----------6}$$

With the use of interval arithmetic [25], the weighted fuzzy performance matrix for representing the overall performance of all alternatives in regard to each criterion can then be determined by multiplying the criteria weights (w_j) and the alternative performance ratings (x_{ij}), given as follows:

$$z = \begin{bmatrix} w_1 x_{11} & w_2 x_{12} & - & w_m x_{11} \\ w_1 x_{21} & w_2 x_{22} & - & w_m x_{2m} \\ - & - & - & - \\ w_1 x_{n1} & w_1 x_{n2} & - & w_m x_{nm} \end{bmatrix} \quad \text{----------7}$$

To avoid the complicated and unreliable process of comparing and ranking fuzzy utilities often required in fuzzy multi-criteria analysis for determining the overall performance of each alternative across all criteria, the defuzzification method based on geometric centre of a fuzzy number [7] can be used in (7), resulting in the determination

$$R = \begin{bmatrix} r_{11} & r_{12} & - & r_{1m} \\ r_{21} & r_{22} & - & r_{2m} \\ - & - & - & - \\ r_{n1} & r_{n2} & - & r_{nm} \end{bmatrix} \quad \text{----------8}$$

To rank alternatives based on (8) the concept of the positive and negative ideal solutions (alternatives) is used. The positive (or negative) ideal solution consists of the best (or worst) criteria values attainable from all the alternatives if each criterion takes monotonically increasing or decreasing values [15, 24]. The most preferred alternative should not only have the shortest distance from the positive ideal solution, but also have the longest distance from the negative ideal solution [24, 41, 42]. This concept has been widely used in various MA models for solving practical decision problems [7, 41, 42] due to (a) its simplicity and comprehensibility in concept, (b) its computational efficiency, and (c) its ability to measure the relative performance of the decision alternatives in a simple mathematical form.

Based on the concept presented above, the positive ideal solution A^+ and the negative ideal solution A^-, can be determined by

$$r^+ = (r_1^+, r_2^+, \ldots\ldots, r_m^+),$$

$$r^- = (r_1^-, r_2^-, \ldots\ldots, r_m^-) \qquad \text{----- 9}$$

where

$$r_j^+ = sup(r_{1j}, r_{2j}, \ldots\ldots, r_{nj}),$$
$$r_j^- = inf(r_{1j}, r_{2j}, \ldots\ldots, r_{nj}) \quad \text{---- 10}$$

from (8) to (10) the Hamming distance between alternative A_i and the positive solution and the negative ideal solution can be calculated respectively by (11)

$$S_i^+ = \sum_{j=1}^{m} (r_j^+ - r_{ij}) \qquad S_i^- = \sum_{j=1}^{m} (r_{ij} - r_j^-) \qquad \ldots (11)$$

A crisp success index for alternative A_i across all the criteria can be determined by (12). The larger the success index, the more preferred the alternative.

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-}, \quad i = 1,2,\ldots\ldots, n$$

V An Example

To demonstrate the applicability of the proposed multi criteria analysis approach above, this section presents an example in evaluation and selecting an e-market from available e-markets in e-business in an organization. In this assumed situation four evaluation and selection criteria are identified as shown in Table 1 including (a) performance, (b) Economic value, (c) Process Capability, and (d) E-business Maturity. To simplify the calculation process, the associated sub-criteria are not considered although they can easily be included in any evaluation and selection of e-markets in real situation using the proposed approach. Four potential e-markets are to be evaluated with respect to these four criteria, leading to one e-market being selected for conducting e-business.

Using the pair wise comparison technique based on the linguistic variables defined as in Table I , a fuzzy reciprocal judgment matrix for the performance of alternative e-markets in regarding to criterion C_1 can be determined as

$$C_1 = \begin{matrix} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} \begin{bmatrix} \tilde{1} & \tilde{3} & \tilde{7} & \tilde{5} \\ \tilde{3}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{7}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{5}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix}$$

$$C_2 = \begin{matrix} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} \begin{bmatrix} A_1 & A_2 & A_3 & A_4 \\ \tilde{1} & \tilde{5} & \tilde{5} & \tilde{3}^{-1} \\ \tilde{5}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{5}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix}$$

$$C_3 = \begin{matrix} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} \begin{bmatrix} A_1 & A_2 & A_3 & A_4 \\ \tilde{1} & \tilde{9} & \tilde{3}^{-1} & \tilde{5} \\ \tilde{9}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{3} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{5}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix}$$

$$C_4 = \begin{matrix} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{matrix} \begin{bmatrix} A_1 & A_2 & A_3 & A_4 \\ \tilde{1} & \tilde{3}^{-1} & \tilde{7}^{-1} & \tilde{5}^{-1} \\ \tilde{3} & \tilde{1} & \tilde{9}^{-1} & \tilde{3} \\ \tilde{7} & \tilde{9} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{5} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix}$$

based on (2) and (3) , the decision matrix for the information systems selection problem can be calculated as

$$X = \begin{bmatrix} (0.17,0.45,1.05) & (0.14,0.37,1.05) & (0.19,0.41,0.88) & (0.03,0.05,0.20) \\ (0.16,0.38,0.87) & (0.18,0.43,0.87) & (0.15,0.36,0.77) & (0.05,0.20,0.57) \\ (0.02,0.04,0.19) & (0.03,0.05,0.19) & (0.04,0.12,0.37) & (0.23,0.49,1.08) \\ (0.04,0.13,0.41) & (0.05,0.15,0.41) & (0.04,0.12,0.37) & (0.09,0.26,0.70) \end{bmatrix}$$

To determine the relative importance of the selection criteria, pair wise comparison is used based on the linguistic variables defined as in Table 1, resulting in the determination of a fuzzy judgment matrix as

$$W = \begin{matrix} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \end{matrix} \begin{bmatrix} C_1 & C_2 & C_3 & C_4 \\ \tilde{1} & \tilde{7} & \tilde{9} & \tilde{5} \\ \tilde{7}^{-1} & \tilde{1} & \tilde{9} & \tilde{3} \\ \tilde{9}^{-1} & \tilde{9}^{-1} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{5}^{-1} & \tilde{3}^{-1} & \tilde{3} & \tilde{1} \end{bmatrix}$$

Using the fuzzy system analysis in [12], the fuzzy criteria weights (W_j,j=1,2,3,4) can be calculated as

W_1=(0.35,0.53,1.04) W_2=(0.15,0.32,0.67)
W_3=(0.02,0.04,0.15) W_4=90.04,0.11,0.32)

Using the fuzzy arithmetic operations on (4), the weighted fuzzy performance matrix for the information systems projects selection problem can be determined as following the approach illustrated in (5) to (19), an overall performance index for each information systems projects alternative across all criteria can be calculated in a simple and efficient manner. Table 2 shows the overall performance index of all alternatives and their corresponding rankings.

Alternative A_2 is the preferred choice

TABLE III THE OVERALL PERFORMANCE INDEX AND RANKING OF THIRD PARTY E-MARKET PROVIDERS

E-markets	Success Index	Ranking
A_1	0.58	2
A_2	0.83	1
A_3	0.14	4
A_4	0.29	3

VI. CONCLUSION

Evaluating and selecting e-markets in organizations for successfully conducting business-to-business e-business has become increasingly important for organizations due to the increasing popularity of e-markets in today's competitive environment. The evaluation and selection process, however, is complex and challenging due to the multi-dimensional nature of the selection process and the presence of subjectiveness and imprecision inherent in the human decision making process. This paper has presented a multicriteria analysis approach for effectively solving the e-market evaluation and selection problem. An example is presented which shows that the proposed approach is applicable for effectively solving the general third-party e-market evaluation and selection problem under uncertainty.

References

[1] . Bakos, "Reducing buyer search costs: implications for electronic marketplaces", *Management Science*, vol. 43, no.2, 1997; pp. 1676-1692.

K. Barryman, L. Harrington, D. Layton-Rodin, and V. Rerolle, "Electronic commerce: three emerging strategies." *The McKingsey Quartely*, vol.1, 1998, pp.152-159.

[2] Butler, J. S. Dyer, J. Jia, and K. Tomak, "Enabling e-transactions with multi-attribute preference models", *European Journal of Operational Research*, vol. 186, 2008, pp. 748-765.

[3] Buyukozkan, "A success index to evaluate e-marketplaces", *Production Planning and Control*, vol. 15, no. 7, 2004, pp. 761-774.

[4] G. Buyukozkan, "Multi-criteria decision making for e-marketplace selection", *Internet Research*, vol. 14, no. 2, 2004, pp.139-154.

[5] S. H. Chen, "Ranking fuzzy numbers with maximising set and minimising set", *Fuzzy Sets and Systems*, vol. 17, 1985, pp. 113-129.

[6] S. J. Chen, and C. L. Hwang, *Fuzzy Multiple Attribute Decision Making: Methods and Applications*. New York: Springer-Verlag, 1992.

[7] Q. Dai and R. Kauffman, "Partnering for perfection: strategic alliances", in Tomak, K. (Ed.) *Advances in the Economics of Information Systems*, Harrisburg, PA: Idea Group Publishing, 2004, pp. 43-79.

[8] A. Das and L. Buddress, "Evaluating prospective e-providers: An empirical study", *The Journal of Supply Chain Management*, Fall, 2007, pp. 31-46.

[9] E. M. Daniel, J. Hoxmeier, A. White, and A. Smart, "A framework for the sustainability of e-marketplaces", *Business Process Management Journal*, vol. 10, no.3, 2004, pp. 277-290.

[10] H. Deng, "A fuzzy approach to selecting information systems projects", *International Journal of Computers and Information Sciences*, vol. 6, no. 1, 2005, pp. 13-21.

[11] H. Deng, "Multicriteria analysis with fuzzy pairwise comparison" *International Journal of Approximate Reasoning*, vol. 21, 1999, pp. 215-231.

[12] H. Deng, H., and C. H. Yeh, "Fuzzy ranking of discrete multicriteria alternatives", *Proceedings of the IEEE Second International Conference on Intelligent Processing Systems*, Gold Coast, Australia, 1998, pp. 344-348.

[13] H. Deng, H., and C. H. Yeh, "Simulation-based evaluation of defuzzification-based approaches to fuzzy multiattribute decision making", *IEEE Transactions on Systems, Man, and Cybernetics*, vol. 36, no. 5, 2006, pp. 968-977.
[14] H. Deng, C. H. Yeh, and R. J. Willis, "Inter-company comparison using modified TOPSIS with objective weights", *Computers and Operations Research,* vol. 27, 2000, pp. 963-973.
[15] N. F. Doherty and L. McAulay, "Towards the formulation of a comprehensive framework for the evaluation of investments in sell-side e-commerce", *Evaluation and Program Planning*, vol. 25, 2002, pp. 159-165.
[16] W. Dou and Chou D. C., "A structural analysis of business-to-business digital markets", *Industrial Marketing Management*, vol. 31, 2002, pp. 165-176.
[17]Emarketservices,"Directoryof electronic marketplaces",h*ttp://www.emarketservices.com/start/eMarket-Directory/index.html,* 2007.
[18] Fu et al. (2007). "The impact of market freedom on the adoption of third-party electronic marketplaces: A fuzzy AHP analysis." *Industrial Marketing Management*, 2007.
[19] M. Grieger, "Electronic marketplaces: A literature review and a call for supply chain management research", *European Journal of Operational Research*, vol. 144, no. 2, 2003, pp. 280-294.

[20] J. L. Hopkins and D. F. Kehoe, "The theory and development of a relationship matrix-based approach to evaluating e-marketplaces", *Electronic Markets*, vol. 16, no. 3, 2006, pp. 245-260.
[21] J. L. Hopkins and D. F. Kehoe, "Testing an interrelationship matrix-based method designed for assisting in e-marketplace selection", *Electronic Markets*, vol. 17, no. 3, 2007, pp. 210-230.
[22] M. Howard, R. Vidgen, and P. Powell, "Automotive e-hubs: exploring motivations and barriers to collaboration and interaction", *Journal of Strategic Information Systems*, vol.15, no. 1, 2006, pp. 51-57.
[23] C. L. Hwang, and K. S. Yoon, *Multiple Attribute Decision Making: Methods and Applications*. Berlin: Springer, 1981.
[24] A. Kaufmann and M. M. Gupta, *Introduction to Fuzzy Arithmetic Theory and Applications*. Boston: International Thomson Computer Press, 1991.
[25] W. P. Lee, "Towards agent-based decision making in the electronic marketplace: Interactive recommendation and automated negotiation", *Expert Systems with Applications*, vol. 27, 2004, pp. 665-679.
[26] L. J. Lipis, R. Villars, D. Byron, and V. Turner, "Putting markets in place: an e-marketplace definition and forecast", *http://www.idc.com,* 2000.
[27] C. Milliou and E. Petrakis, "Business-to-business electronic marketplaces: Joining a public or creating a private", *International Journal of Finance and Economics*, vol. 9, 20004, pp. 99-112.
[28] G. Nairn, "Winds of change sweep through the marketplace", *Financial Times*, Connectis, 2000, pp.11
[29] K. J. Petersen, J. A. Ogden, and P. L. Carter, "B2B e-marketplaces: a typology by functionality", *International Journal of Physical Distribution & Logistics Management*, vol. 37, no. 1, 2007, pp. 4-18.
[30] T. Ravichandran, S. Pant, and D. Chatterjee, "Impact of industry structure and product characteristics on the structure of B2B vertial hubs", *IEEE Transaction on Engineering Management*, vol. 54, no. 3, 2007, pp. 506-520.
[31] T. L. Saaty, *The Analytical Hierarchy Process, Planning, Priority, Resource Allocation*. New York: RWS Publications, 1990.
[32] J. Sarkis and R. P. Sundarraj, "Evolution of brokering; paradigms in e-commerce enabled manufacturing", *International Journal of Production Economics*, vol. 75, 2002, pp. 21-31.
[33] H. Sharifi, D. F. Kehoe, and J. Hopkins, "A classification and selection model of e-marketplaces for better alignment of supply chains", *Journal of Enterprise Information Management*, vol. 19, no. 5, 2006, pp. 483-503.
[34] C. Soh, M. L. Markus, H. G. Kim, "Electronic marketplaces and price transparency:

strategy, information technology, and success", MIS Quarterly, vol. 30, no. 3, 2006, pp.705-723.
[35] J. Son and I. Benbasat, "Organizational buyer's adoption and use of B2B electronic markets: efficiency and legitimacy-oriented perspectives", *Journal of Management Information Systems*, vol. 24, no. 1, 2007, pp. 55-99.
[36] C. Standing and C. Lin, "Organizational evaluation of the benefits, constraints, and satisfaction of business-to-business electronic commerce", *International Journal of Electronic Commerce*, vol. 11, no. 3, 2007, pp. 107-134.
[37] The Economist, "Shopping around the Web: a survey of e-Commerce", *http://www.economist.com/editorial/freeforall/20000226/index_surve y.html*, 2000.
[38] P. Timmers, "Business models for electronic markets", *European Commission Focus*, vol. 8, no. 2, 1998, pp. 3-8.
[39] C. H.Yeh, and H. Deng, "A practical approach to fuzzy utilities comparison in fuzzy multicriteria analysis", *International Journal of Approximate Reasoning*, vol. 35, no. 2, 2004, pp. 179-194.
[40] C. H Yeh, H. Deng, and H. Pan, "Multi-criteria analysis for dredger dispatching under uncertainty" *Journal of the Operational Research Society*, vol. 50, 1999, pp. 35–43.
[41] C. H. Yeh, H. Deng, and Y. H. Chang, "Fuzzy multicriteria analysis for performance evaluation of bus companies", *European Journal of Operational Research*, vol. 126, no. 3, 2000, pp. 1-15.
[42] L. A. Zadeh, "Outline of a new approach to the analysis of complex system and decision process", *IEEE Transactions on Systems Man and Cybernetics*, vol. 2, 1973, pp. 28-44.
[43] B. Wall, H. Jagdev, and J. Brown, "A review of eBusiness and digital business-applications, models and trends", *Production Planning and Control*, vol.18, no. 3, 2007, pp. 239-260.
[44] S. Wang, N. P. Archer, and W. Zheng, "An exploratory study of electronic marketplace adoption: A multiple perspective view", *Electronic Markets*, vol. 16, no. 4, 2006, pp. 337-348.
[45] R. Wise and D. Morrison, "Beyond the exchange: the future of B2B", *Harvard Business Review*, November/December, 2000, pp. 86-96.