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ABSTRACT： In this paper, a model and an evaluation method are proposed expanding technology assessment model (TAM) to enable a comprehensive evaluation and selection of socio technical systems relevant in today's Internet environment. The proposed evaluation model called WOSP is practical and easy to integrate in decision support system tools for comparing IT software involving socio-technical factors.

Keywords: Assessment of Information Technology, Socio-Technical Systems, Conjoint Analysis

1. Introduction

The use of information technologies, including computers, in today's organizations has increased dramatically in recent years. A major reason for this is that Information Technology has for some time now been considered the primary survival factor for many organizations today (Sylla and Wen 2002). By some estimates, over the last two decades, approximately 50% of all new capital investment in organizations has been in information technology (Westland and Clark 2000). As far back as in the late '80s, 0.5 trillion dollars per year was already being spent on information systems. Further, firms were investing between 1.5% and 3.0% of their annual revenue in IT (Ian 1989), while approximately one third of the annual capital investments by US corporations was in IT. By other estimates, the total worldwide expenditure on information technology exceeded one trillion US dollars per annum in 2001, with approximately a 10% annual compounded growth rate (Seddon et al., 2002). These estimates give an idea of the significance of IT in business and industry today.

In fact, it is clear that in recent years, IT, more than any other technology has been considered as the most critical success factor of business organizations in the increasingly global competitive environment. The benefits that can be derived from IT investment give ample reason for the interest. The benefits can broadly be classified into four categories with the following purposes (Sylla and Wen 2002):

- Increasing productivity and the performance of operating processes. Facilitating support for management.
- Gaining competitive advantage.
- Providing a good framework for the restructuring or transformation of business.

These and other forms of benefits provided by IT were previously documented in other forms in standard texts on IT investment such as (Farbey, Land et al., 1993; Applegate, McFarlan et al., 1996, Sethi and King, 1994).

This paper presents an alternative model of IT evaluation which includes the full spectrum of socio technical factors and interactions among the human users and decision makers in the context of Web 2 environment.

2. Description of Information and Socio-Technical Systems

A system can be defined as "a purposeful collection of interrelated components that work together to achieve some objective" (Sommerville, 2000). In the specific case of information systems, the stimulus for system development typically is rooted in an organizational problem or opportunity (Browne and Rogich, 2001). According to Sommerville (2004), systems that include software can be divided into two broad categories, namely (1) Technical computer-based systems and (2) socio-technical systems.

Technical computer-based systems are systems that include hardware and software components but exclude procedures and processes. Examples include television, mobile phones, and most personal computer software. These systems are used by individuals and organizations for specific purposes. However, knowledge of these purposes is not part of the system.

Socio-technical systems include one or more technical systems, but also include knowledge of how the system should be used to achieve some broader objective. These systems have defined operational processes, and include people, who are the operators, as inherent parts of the system. Also, socio-technical systems are governed by organizational policies and rules, and may be affected by external constraints such as national rules and regulatory policies.

Some of the essential characteristics of socio-technical systems include the following:

1. They have emergent properties that are system-wide, rather than being particular to specific parts of the system. The emergent properties depend both on the system components and the relationships between them. Such properties can be evaluated only after the entire system has been assembled.

2. They are frequently nondeterministic. Thus, they may not always behave in the same way. For instance, when presented with a given input, they may not always return the same output. One reason for this is that the system's behavior is dependent on human operators who do not always behave in the same way. Moreover, use of the system may create new relationships between the system components, leading to a change in its emergent behavior.

3. The extent to which the system supports organizational objectives depends not only on the system, but also on the stability of these objectives, the relationships and conflicts between them, and the interpretation of the objectives by the organization's staff. Thus reinterpretation of an objective that a system was successfully designed to support may result in the system being viewed as a failure.

Given the inherent flexibility of software, it is often used to rectify unexpected situations or problems in a system. For example, it is very common to opt to enhance the software capabilities of a system without increasing the hardware costs.

Of particular interest to information system research are socio-technical systems that include hardware and software, have defined operational processes, and offer an interface, implemented in software, to human users.

3. Needs for Including Socio Technical Factors in Evaluation Systems

Thus, a key objective of much of the research done in IS has to do with assessing the value of the information technology in organizations and understanding the determinants of that value. The goal of such research is to help firms deploy and manage their IT resources better so as to enhance overall effectiveness (Taylor and Todd 1995). Furthermore, such research is critical in providing information that senior executives need to justify the huge investments in computers and related technology (Brynjolfsson, 1993). However, should IT evaluation be limited to TAM factors of functionality and usability proposed by Davis (1989)?

3.1 Web of System Performance Model

Whitworth and Zaic (2003), suggest yet another model for explaining those qualities of software systems that are relevant for user acceptance beyond functionality and usability. This model, called the Web of System Performance (WOSP) model, is derived from systems theory. Systems theory has been defined as “the trans-disciplinary study of the organization of phenomena, independent of their substance, type, or spatial or temporal scale of existence” (Principia Cybernetica for online encyclopedia). It investigates both the principles common to all complex entities, and the models which can be used to describe them. And in common with all other complex systems found in nature, the performance of information systems involves multiple aspects. A system’s performance in this context is defined as how successfully it interacts with its environment. The aspects can be grouped into the basic system elements of boundary, internal structure, effectors, and receptors. Each of these elements in turn has a dual role in system performance that seeks to maximize opportunity or value, and minimize risk or loss. This gives rise to eight system performance goals, which are the fundamental attributes of the system. The elements and their system performance purposes or goals are:

Effectors:

Functionality – to act on the environment

Usability – to reduce the cost of any action

Boundary:

Security – to prevent unwelcome entry

Extendibility – to use outside objects or materials

Structure:

Reliability – to continue performing the same despite internal change

Flexibility – to perform differently given external change

Receptors:

Connectivity – to exchange social meaning

Confidentiality – to control or limit social meaning exchange

4. Fundamental Research Question and Choice of Model

How do the users rate these criteria relative to each other for purposes of system evaluation?

The research involves the study of how information system performance is perceived to vary with the eight WOSP variables, or how each of the eight criteria influences the rating of software from the perspective of a user. The research problem would therefore involve some form of multivariate analysis. According to available literature (Hair et al., 1995), the selection of the appropriate multivariate technique to use for analysis depends on three main guidelines.

Conjoint Analysis: This method of analysis arose out of a need to analyze the effects of predictor variables that are qualitatively expressed, or weakly measured. It portrays a user's decision realistically as a trade-off among several attributes or factors. Conjoint analysis is unique in that it is able to accommodate a metric or non-metric dependent variable, and that it is able to make use of categorical predictor variables. The major objectives of conjoint analysis include:

- Determining the contributions of predictor variables, and their respective values to the determination of consumer or user preferences.
- Establishing a valid model of consumer preferences that can be used to predict user acceptance of any combination of attributes, including those not originally evaluated by consumers.

4.1 Evaluation using Conjoint Analysis.

Conjoint analysis enables an understanding of how subjects develop preferences for products or services. It is based on the idea that people evaluate the value of a product or service by adding up the separate amounts of utility provided by each of the attributes of the product or service. A unique feature of conjoint analysis among multivariate analysis methods is the fact that a set of hypothetical products or services are first constructed by combining the attributes that make up the product or service at various levels. The hypothetical products and services are then presented to the subject who is then required to indicate his preference from among the set as he practically would in real life. Based on the subject's preferences, the technique is able to determine the importance to that individual of each attribute and attribute level.

For the technique to be applied successfully it must be possible to describe the product or service fully in terms of its attributes/factors and the various levels these attributes can attain. A product or service with a particular set of levels or values of the various factors is referred to as a treatment or a stimulus.

Analysis of a subject's evaluation or preference of specific combinations of treatments gives the subject's preference structure, which shows not only how important each factor is to the individual's decision, but the importance of the various levels within each factor. In ranking the combinations of treatments, the individuals must make a tradeoff as they must take the factors and levels they like as well as those factors and levels that they do not like in a particular stimulus and make an overall judgment. The overall preference for a particular stimulus can be regarded as the total worth of that product or service. Then the factors in their various levels would be considered part-worth of the product. This can be represented in the general form of a conjoint model as follows:

Total Worth for product = Part-worth of level_i for factor_1 +

part-worth of $level_j$ for $factor_2$ + …+

part-worth of $level_n$ for $factor_m$

Where the product or service has m factors, each factor is set at two or more levels. The particular stimulus consists of $level_i$ of $factor_1$, $level_j$ of $factor_2$, and so on up to $level_n$ for $factor_m$. Detailed descriptions of these factors along with the experimental design features and analyses are omitted here, but are available in Mahinda (2010). Other experimental validations are found in (Whitworth et al., 2008)

Results

Factor	Std. Dev.	Av. Importance	99% Confidence	%age above 12.5%
Security	4.40	20.97	16.28 - 25.66	73.08
Reliability	13.13	14.06	10.86 - 17.26	51.92
Privacy	7.31	13.14	10.65 - 15.63	48.08
Usability	5.25	12.92	10.04 -15.80	46.15
Functionality	8.95	11.59	8.99 - 14.19	40.38
Connectivity	8.06	11.34	8.73 - 13.95	44.23
Extendibility	6.98	7.99	6.42 - 9.56	19.23
Flexibility	7.27	7.98	6.11 - 9.85	19.23

Security: The average importance for security was the highest among the eight factors. The expected average importance was lower than the confidence interval. This factor also had the highest percentage of subjects with an average importance greater than 12.5%.

Reliability: The average importance for reliability was the second highest of the eight factors. The expected average importance was within the confidence interval. This factor also had the second highest percentage of subjects giving it an average importance greater than 12.5%.

Privacy**:** This factor had the third highest average importance for the subject group. The expected average importance was within the confidence interval. Privacy had the third highest percentage of subjects giving it an average importance greater than 12.5%.

Usability: Usability had the fourth highest subject group average importance. Also, the expected average importance was within the confidence interval. Usability had the fourth highest percentage of subjects giving it an average importance greater than 12.5%.

Functionality: This performance factor had the fifth highest subject group average importance. The expected average importance fell within the confidence interval. The factor had the sixth highest percentage of subjects giving it an average importance greater than 12.5%.

Connectivity: This factor had the sixth highest subject group average importance. The expected average importance was within the confidence interval. Connectivity ranked fifth in percentage of subjects giving it an average importance greater than 12.5%.

Extendibility: Extendibility had the seventh highest and second lowest subject group average importance. The expected average importance falls beyond the confidence interval. It also had the seventh highest, or second lowest percentage of subjects giving it an average importance of 12.5% or higher.

Flexibility: This factor had the eighth and lowest average importance from the subject group. The expected average importance is beyond the confidence interval. This factor also had the lowest percentage of subjects giving it an average importance of 12.5% or greater.

5. Discussions

It is surprising that functionality and usability, which TAM predicts as primary user selection criteria, rank fourth and fifth, respectively. While TAM has been proven to be valid, and may be the primary user acceptance theory, it seems not to represent the primary user acceptance factors for social-technical systems.

It is also notable that reliability has a distinctly different weight from security, suggesting that software users distinguish these concepts from each other. While some technology acceptance models present reliability as an aspect of security (Laprie, 1992), others see it as "the ability of a system to resist attack" (Littlewood and Strigini, 2000). This approach explains why mechanisms that increase fault-tolerance (reliability) can reduce system security (which is illogical if reliability is an aspect of security). Recent models reclaim the reliability/security distinction, as the first is based on provision of service, while the second is based on denial of service (Jonsson, 1998).

Similarly, while security has been described in various IS literature as including confidentiality (privacy) as an attribute (European Commission 1993), the results suggest that security and privacy are distinct in the minds of users. Likewise, while flexibility has been suggested to include scalability (an aspect of extendibility) and connectivity (Knoll and Jarvenpaa 1994), the results imply that flexibility, extendibility and connectivity are recognized as distinct concepts by users.

Despite the recent IS interest in flexibility under terms like mobility and agility, this study found flexibility had the lowest relative importance. This may have been because flexibility is not very relevant to browser software, or because many users do not fully understand or appreciate its value. Or it may be because although flexibility is very important to system designers and programmers, it is not so important to users.

Generally, of the eight factors the WOSP model presents, extendibility, flexibility and connectivity are the least known. More familiar factors like security, usability and reliability may be rated as more important, following the availability heuristic (Kahneman, Slovic and Tversky 1982). However, as users become more knowledgeable, and as use of social-technical systems becomes more established, the appreciation of the various performance factors may change, with an accompanying change in the rating of software acceptance factors.

This research found that the WOSP model provides a more comprehensive set of criteria than any other current model does for the user evaluation of the intrinsic technical performance factors of complex socio-technical information systems such as browsers and other tools allowing for the human interactions in cyberspace.

References

Applegate, L. M., F. W. McFarlan, et al. (1996). Corporate Information Systems. Boston.

Brynjolfsson, E. (1993). The productivity paradox of information technology. Communications of the ACM 36(12), 66-77.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3.), 319-339.

EC (1993). Information Technology Security Evaluation Criteria.

Farbey, B., F. Land, et al. (1993). How to Assess Your IT Investment. Oxford, Butterworth Heinemann.

Hall, D., and Mansfield, R. (1995). Relationships of age and seniority with career variables of engineers and scientists. Journal of Applied Psychology (60:2), 201-210.

Ian, M. (1989). Computing matters: making it work to best effect. Management Today, 109-110.

Jonsson, E. (1998). An integrated framework for security and dependability. Paper presented at the NSPW, Charlottesville, VA, USA.

Kahneman, D., P. Slovic, et al. (1982). Judgment Under Uncertainty. New York, Cambridge University Press.

Knoll, K., and S. L. Jarvenpaa (1994). Information technology alignment or "fit" in highly turbulent environments: the concept of flexibility. Proceedings of the 1994 Computer Personnel Research Conference on Reinventing IS: Managing Information Technology in Changing Organizations, 1-14.

Laprie, J. C. (1992). Dependability: basic concepts and terminology. Springer-Verlag 5.

Littlewood, B., and L. Strigini (2000). Software reliability and dependability: a roadmap. Proceedings of the conference on The future of Software engineering, 175-188.

Moore, G. C. and I. Benbasat (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research, 2 (3), 192-222.

Seddon, P. B., V. Graeser, et al. (2002). Measuring organizational IS effectiveness an overview and update of senior management perspectives. ACM SIGMIS Database, 33 (2), 11-28.

Sethi, V. and W. R. King (1994). Development measures to assess the extent to which an information technology application provides competitive advantage. Management Science, 40 (12), 1601-1627.

Sommerville, I. (2000). Software Engineering. Pearson Education.

Sommerville, I. (2004). Software Engineering. Upper Saddle River NJ, Pearson Education.

Sylla, C. and H. J. Wen (2002). A conceptual framework for evaluation of information technology investments. Int. J. Technology Management, 24(2), 236-261.

Taylor, S. and P. A. Todd (1995). Understanding information technology usage: a test of competing models. Information Systems Research, 6, (2), 144-176.

Westland, J. C. and T. H. K. Clark (2000). Global Electronic Commerce. Cambridge, MA, MIT Press.

Whitworth, B. and M. Zaic (2003). The WOSP model: balanced information system design and evaluation. Communications for the Association for Information Systems, 12, 258-282.

Whitworth, B., Bañuls, V., Sylla, C., & Mahinda, E. (2008).Expanding the Criteria for Evaluating Socio-Technical Software, IEEE Transaction on Systems Man & Cybernetics, Part A, Systems and Humans, 38 (4), July 2008, 777 – 790.