

Cost-benefit factor analysis in e-services using bayesian networks

Jie Lu^{a,*}, Chenggang Bai^b, Guangquan Zhang^a

^a Faculty of Information Technology, University of Technology, Sydney P.O. Box 123, Broadway, NSW 2007, Australia

^b Department of Automatic Control, Beijing University of Aeronautics and Astronautics, China

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ABSTRACT

This study applies Bayesian network techniques to analyze and verify the relationships among cost factors and benefit factors in e-service systems. This study first establishes a Bayesian network for e-service cost-benefit factor relationships based on our previous study [Lu, J. & Zhang, G. Q. (2003). Cost benefit factor analysis in e-services. *International Journal of Service Industry Management (IJSIM)*, 14(5), 570–595]. It then calculates conditional probability distributions among these factors shown in the Bayesian network. Finally it runs a Junction-tree algorithm to conduct inference for verifying these cost-benefit factor relationships, and the data collected through a survey is as evidences in the inference process. Through the above application of Bayesian network techniques a set of useful findings is obtained for the costs involved in e-service developments against the benefits received by adopting these e-service systems. The case of 'increased investments in maintaining e-services' would significantly contribute to 'enhancing perceived company image', and the case of 'increased investments in security of e-service systems' would bring high benefits in 'building customer relationships' and 'improving cooperation between companies'. These findings have great potential to improve the strategic planning of businesses by determining more effective investments items and adopting more suitable development activities in e-service systems and applications.

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1. Introduction

Since the mid-1990s, businesses have spent quite a bit of time, money and effort developing web-based electronic service (e-service) systems. These systems assist businesses in building more effective customer relationships and gaining competitive advantage through providing interactive, personalized, faster e-services to customers (Chidambaram, 2001). Businesses in the earlier stages of employing web-based e-service systems had little data, knowledge, and experience for assessing and evaluating the potential impacts and benefits of e-services for organizations. Organizational efforts were largely geared toward customer service provision with little thought to identifying and measuring the costs involved in e-service development against the benefits received by adopting e-services. After several years' experience of e-service provision, businesses now urgently need to do it for planning their further development in e-services. Importantly, businesses have obtained related e-service systems running data and knowledge, which can directly help identify which items of investments for an e-service system effectively contribute to what benefit aspects of business objectives.

With the wide development of e-services, researchers have expressed increasing interest in evaluating the success, quality, usability and benefit of e-service systems from various views and using various methods (DeLone & McLean, 2004; Wade & Nevo, 2005). A major focus in this area is the evaluation for the features, functions or usability of e-service systems. Typical approaches used are testing, inspection and inquiry (Hahn & Kauffman, 2002) through a web search or a desk survey such as the results reported in Ng, Pan, and Wilson (1998), Smith (2001), Lu, Tang, and McCullough (2001). Another type of related research is the evaluation of customers' satisfaction for e-services. Questionnaire-based survey and multi-criteria evaluation systems are widely used to conduct this kind of research such as Lin (2003) and Srinivasan et al. (2002). Moreover, some significant results are reported in the establishment of e-service evaluation models and framework, such as the results shown in Lee, Seddon, and Corbitt (1999), Zhang and von Dran (2000) and Giaglis et al. (1999).

However, the research discussed above only focuses on the evaluation of an e-service system itself from the user point of view by measuring either customer satisfaction or functionality of the e-service system. Although some research addresses the view of e-service providers such as Giaglis, Paul, and Doukidis (1999) presented a case study of e-commerce investment evaluation, Drinjak et al. (2001) and Piris et al. (2004) investigated the perceived business benefits of investing in e-service systems, and

* Corresponding author. Tel.: +61 02 95141838.

E-mail addresses: jjelu@it.uts.edu.au (J. Lu), bcg@buaa.edu.cn (C. Bai), zhangg@it.uts.edu.au (G. Zhang).

Amir, Awerbuch, and Borgstrom (2000) created a cost-benefit framework for online system evaluation, lack of exploration and deep analysis of possible relations to link these investment items with related business benefits.

Furthermore, businesses would like to know if their investments in e-service systems are successful by conducting cost and benefit analysis. The investments (costs) include e-service related software development, database maintenance, website establishment, staff training and other items. Similarly, the benefits obtained through e-service applications include many aspects, such as increasing the number of customers, better business image, and competitive advantages. Therefore, businesses, as e-service providers, need to know which item(s) of their investments are more important and effective than other items for achieving their business objectives, and also which item(s) of their investments can bring more obvious benefits for certain aspect(s) of the businesses. These results will directly or indirectly support better business strategy making in e-service application developments.

Our previous research reported in (Lu & Zhang, 2003) identified some inter-relationships and interactive impacts among costs and benefits via providing e-services to customers by using the linear regression and ANOVA analysis approaches. Since some inter-relationships among the above mentioned cost-benefit factors may be non-linear, as a further study, this paper reports how these cost-benefit factor relationships are verified and how uncertain relationships are identified by applying the Bayesian network techniques.

After the introduction, this paper outlines our previous work including an e-service cost-benefit factor framework, data collection process, and a cost-benefit factor-relation model in Section 2. Section 3 analyses how Bayesian network techniques are applied in finding any relationships among cost and benefit factors. The detailed process of establishing a cost-benefit Bayesian network and conducting inference among cost and benefit factors are presented in Section 4. Section 5 reports our findings on the relationships between cost and benefit factors in e-service systems. Conclusions and further study are discussed in Section 6.

2. Previous research review

2.1. e-Service cost-benefit factor framework

e-Service cost (C) is the expenses incurred in adopting e-services, such as *expense of setting up e-service* and *maintaining e-service*. e-Service benefit (B) is concerned with the benefits gained through employing e-services. Fig. 1 shows 16 benefit factors and 8 cost factors of e-service system developments and applications.

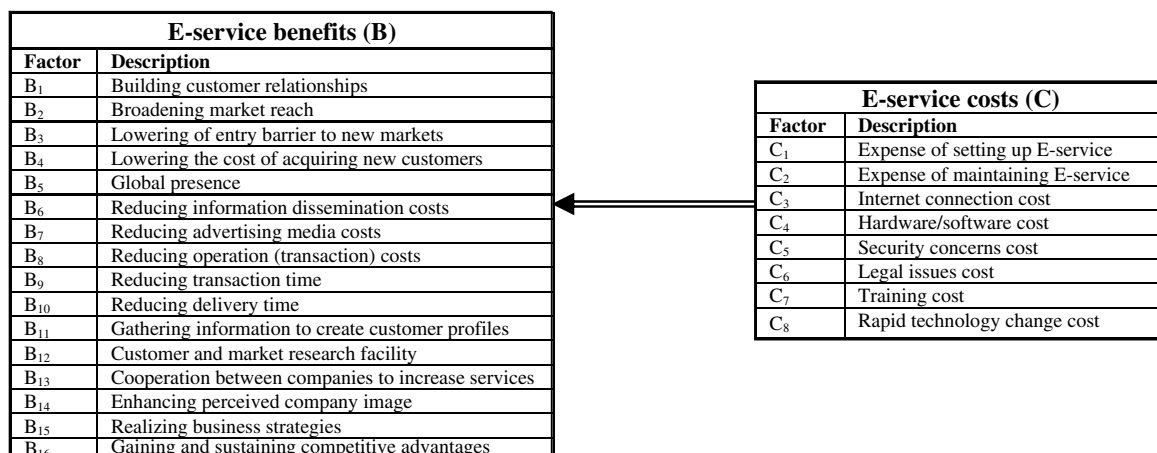


Fig. 1. e-Service cost-benefit factor framework.

All these factors have been well identified and described in Lu and Zhang (2003).

2.2. Data collection

This study collected data concerning e-service development costs and benefits from a sample of Australia companies (e-service providers). In order to select the sample, this study first conducted a web search for finding companies which had adopted e-services on an appropriate level and period. A total of 100 companies were randomly selected from Yellow Pages Online (New South Wales, Australia) <http://www.yellowpages.com.au> under Tourism/Travel (including Accommodation and Entertainment) and IT/Communication categories (including Information Services). A survey was then conducted by sending a questionnaire to these sample companies. Out of 34 questions in the questionnaire, some were related to the costs of developing an e-service application, and some were related to the benefits obtained from developing an e-service application. A total of 48 completed responses were used in this study. In the questionnaire, all cost related questions listed use a five-point Likert scales: 1 – not important at all, 5 – very important. For example, if a company thinks the cost of maintaining an e-service is very important it records the degree of importance of the factor as 5. A 5-point scale is also used for present benefit assessment: 1 – low benefit, 5 – very high benefit. For example, if a company considers that, currently, their e-service only helps a little in customer relationship management, then the company would score the perhaps 1 or 2 on the present benefit assessment for benefit factor B₁ (building customer relationships). Tables 1 and 2 are the summaries about the data collected and used in the study.

The survey result has been firstly used to identify why companies adopt e-service systems, what the main cost factors of current e-service systems are, and what kinds of benefits have been obtained. It has been also used to initially create a cost-benefit factor-relation model which identifies the relationships among cost factors and benefit factors, as described below.

2.3. Initial cost-benefit factor-relation model

By completing a set of ANOVA tests for data collected from the survey, a set of relationships between cost and benefit factors have been obtained (Lu & Zhang, 2003). These relationships reflect that certain cost factors have a significant effect on certain benefit factors. These effects are presented in a cost-benefit factor-relation model (Fig. 2). The lines in the model express the 'effect' relationships between related cost factors and benefit factors. Although

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