Expert Systems with Applications 37 (2010) 3870–3886

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

A MCDM approach for sourcing strategy mix decision in IT projects

Wen-Hsien Tsai [a,*], Jun-Der Leu [a], Jau-Yang Liu [b], Sin-Jin Lin [a], Michael J. Shaw [c]

[a] Department of Business Administration, National Central University, Jhongli, Taoyuan 320, Taiwan
[b] Department of Business Administration, Tungnan University, ShenKeng, Taipei 222, Taiwan
[c] Department of Business Administration, University of Illinois at Urbana-Champaign, Champaign, IL 61820, USA

ARTICLE INFO

Keywords:
Sourcing strategy mix decision
Expert panel
In-sourcing
Co-sourcing
Out-sourcing
Multi-Criteria Decision Making (MCDM)
Decision making trial and evaluation laboratory (DEMATEL)
Analytical network process (ANP)
Zero-one goal programming (ZOGP)

ABSTRACT

It is widely accepted that a business requires constantly evolving strategies that can not only adapt to external environmental change but also identify internal value-added activities and, even more effectively, achieve the goals of management. A sourcing decision about whether to keep IT functions in-house or contract with a third-party service provider is nevertheless entirely strategic and contingent upon organizational goals and contextual and project-specific factors. In order to adequately evaluate such sourcing decision and ensure that tasks can be assigned appropriately, this article proposes a Multi-Criteria Decision Making (MCDM) approach to achieve effective problem-solving by combining the following three methods: decision making trial and evaluation laboratory (DEMATEL), analytical network process (ANP), and zero-one goal programming (ZOGP). The final research results reveal that an organization can – simultaneously – not only take advantage of its internal or external resources to set priorities for task arrangements within the portfolio of sourcing decisions, but also optimize operating strategy and management despite limited resources after consulting with the expert panel.

1. Introduction

1.1. Optimal operations strategy and management

As the out-sourcing services market for information technology (IT) evolves and grows, the sourcing decision models that involved no integrated approach to project management and were prevalent during the 1990s may now be less applicable, given both the decision maker's needs and external environmental change. This is not only because IT or information systems (IS) stays in the era of turbulent marketplaces, global competition, and volatile technology but also because past sourcing decisions used an entire IT/IS department as a unit of analysis rather than treating individual task arrangement of IT/IS projects separately. A business, moreover, has to expose its services to customers, partners and third parties continuously via new technologies in the race for better customer service, shorter cycle times, higher operating efficiency and growth (McBride, 2009). While the Worldwide Web, RFID, location based services and search engines can greatly expand the possibilities, these technologies also place significant burdens on IT infrastructures at a time when insufficient investment is being made.

Traditionally, there have only been two primary choices in the management of IT infrastructures. An organization can either manage its infrastructure in-house, or it can outsource the process to a third party, which will typically take over IT assets and run them with a mixture of on-site and remote services. There is a "third way," often called, "the Co-sourcing model" however, combining the two tried and tested means of in-house team control with remote operations support, utilizing remote-infrastructure management. Under such circumstances, the IT department is best seen not simply as a service provider concerned exclusively with internal resources or capability, but as a resource center with the capability of integrating all internal and external IT resources with the objective of obtaining, managing, effectively utilizing and combining the technology and services required to achieve business objectives. This means that the new operational environment to IT/IS department will be more complex. IT department require an optimal operations strategy which enables IT department take good advantage of internal and external resources efficiently, so that it can concentrate on its core competences and capabilities.

Dominguez Machuca, Alvarez, Domınguez, Garcıa, and Ruız (1995) point out that operations strategy is basic to the development and maintenance of competitive advantage. The key to developing an efficient operations strategy lies in understanding each task attributes usually engaged in IT/IS department and the value that each task can generate in the department. Distinguish task attribute and assessing value-added activities can be achieved by stressing the different priorities of IT/IS task arrangement (Davis,

* Corresponding author. Tel.: +886 3 426 7247; fax: +886 3 422 2891.
E-mail addresses: whtsai@mgt.ncu.edu.tw (W.-H. Tsai), leujunder@mgt.ncu.edu.tw (J.-D. Leu), liu78705@yahoo.com (J.-Y. Liu), annman1204@hotmail.com (S.-J. Lin), mjshaw@uiuc.edu (M.J. Shaw).

0957-4174/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2009.11.031

Aquilano, & Chase, 1999; Krajewski & Rizman, 2000). An organization with such operations strategy will have the capabilities enabling direct CIO of IT/IS department to set priorities for task arrangement within the portfolio of sourcing decisions in order to obtain competitive advantage and operational flexibility.

Davis et al. (1999) state that the operations strategy is a long-term plan which allows the organization to determine the best way to use the IT/IS department's resources so that the end use of the resources and task arrangement are compatible with the corporate operations strategy and objectives. Espino-Rodriquez and Padron-Robaina (2004) argue that one of the aspects that the company must take into account when developing an operations strategy is the relative extent to which operations are outsourced or performed in-house.

The decision to keep IT/IS functions in-house or contract with a third-party service provider is nevertheless entirely strategic and can dramatically impact the bottom line of any organization. Also, the factors motivating the IT department to achieve effective management might be different one another and might include factors other than cost that relate to operations objectives, such as quality, flexibility and technology acquisition. This gives companies different strategic advantages, since they must pursue different competitive priorities simultaneously in order to succeed (Ferdows & De Meyer, 1990; Johnston, Chambers, Harland, Harrison, & Slack, 1993). Consequently, the IT/IS department not only has to take good advantage of internal and external resources but also has to consider new ways of planning and managing operational activities and making sourcing arrangement for the delivery of IT/IS services. Also the role of the IT/IS department, as well as the supply of its contents to organization should be re-examined and aligned more closely to yield a successful operation result after objectives, strategy and alternatives are more clearly understood and articulated.

1.2. The research problems and goals

As is well known, a business requires constantly evolving strategies that can not only adapt to external environmental change but also identify internal value-added activities and, even more effectively, achieve the goals of management. This high value strategy is intrinsically very risky, however, since whichever mode of sourcing – In-sourcing, Out-sourcing or Co-sourcing – has been adopted, they are all conducted in complex, distributed environments. The CIO of the IT/IS department therefore requires sophisticated tools and techniques to ensure that corrective action can be taken proactively and that the tasks involved are exactly assigned and executed with a proper sourcing mode to manage IT infrastructures.

In facing the problem of how to decide the priorities of IS task arrangement and which sourcing mode to operate with a proper sourcing mode, the authors propose a novel hybrid model to optimize the operations strategy for management of an IT project. Our integrated model incorporates the decision making trial and evaluation laboratory method (DEMATEL), integrating these relation weights along with the analytical network process (ANP) and zero-one goal programming (ZOGP) to find an optimal sourcing portfolio for task execution and to achieve objectives using limited resources. Our ultimate objective was to devise a method to help practitioners evaluate how well aligned each sourcing decision is with the company's strategic direction, and to reap the optimal benefits from sourcing decisions regarding task arrangement.

This paper is organized into six sections. Section 1 will briefly describe the optimal operations strategy and management, the research problems and the goals of this study. Section 2 will introduce the three generalized potential sourcing alternatives and conclude five perspectives of operations strategy and management as the evaluation principles of sourcing mode for the sourcing decision. In Section 3, we propose a novel hybrid model to optimize the operations strategy of management of IT projects. In Section 4, an illustrative application of IS sourcing strategy mix decisions is introduced. Discussion of this illustrative application follows in Section 5. In Section 6, we present our conclusions and future research.

2. Literature review

2.1. Potential alternatives of IS sourcing

Certainly, recent trends indicate that a shift is underway, with companies moving away from total In-sourcing or Out-sourcing and towards other models (Liu & Wang, 2009). Generally speaking, management with more easy perceives its sourcing provisioning options in a mutually exclusive manner: In-sourcing or Out-sourcing. Current companies, however, are creating a third option by successfully combining the benefits of both these options while managing their tasks: Co-sourcing. As regards the different types of sourcing approach, therefore, In-sourcing, Out-sourcing and Co-sourcing are the three main sourcing modes in the distribution of task arrangement.

2.1.1. In-sourcing

The most basic level of sourcing modes is the so-called In-sourcing. In-sourcing is a business sourcing decision that is often made to maintain control of certain critical production or competencies. At this level, the provider of In-sourcing services needs to manage the day-to-day activities of the organization, using the organization's own employees and resources. Consequently, the main strategy involved in the use of In-sourcing is to concentrate upon the value-added task, achieve optimum operational efficiency and make good use of internal resources (Venkatesan, 1992). Also, in-sourced tasks are typically limited in number and reflect specific activates along the value chain where the organization can dominate and outperform its competitors and therefore provide unique opportunities to leverage its knowledge assets and know-how to offer a unique value proposition.

Although In-sourcing is often defined as the delegation of operation or job from production within a business to an internal entity that specializes in that operation, this article is not just focused on studying this traditional form of In-sourcing. Instead, the concept and definition of In-sourcing will be extended and endowed with a broader connotation. This new connotation of the In-sourcing will comprehend the concept of some critical services or core competence that an organization should keep it inside and enable the IT department to transform these value contributions to the overall corporate objective, from tactical tasks and transactional activities towards a more strategically focused role. Therefore, In-sourcing a product or service project not only deals with the internal provision and management of information technology products and services but also entails certain competence and resources with full of competitive tactical value or contribution that are conform to long-term operational goal.

A more extensive In-sourcing assignment may involve supporting all aspects of the organization's IT needs, including management of current systems, development of new systems, and management of telecommunications needs. Some of the most complex In-sourcing assignments involve certain tasks of identifying demand, formulating policy and strategy, instituting specifications and integrating resources or tasks of the organization and even managing in-house teams in partnership with outsourced teams to leverage the expertise and economical resources of suppliers while retaining control and knowledge throughout the project with the company's employees.

2.1.2. Out-sourcing

Yet another way of traditional sourcing approaches is Out-sourcing. Lacity and Hirschheim (1993) regard Out-sourcing as a form of sub-contracting of activities previously carried out within the company, i.e., the substitution of a service provided by the company. The term, "Out-sourcing," is usually used when companies opt for the disintegration of activities. Out-sourcing works well for administrative tasks that primarily address employee needs and require little ongoing employer involvement (Yang & Huang, 2000). In recent years, however, many other functions in various sectors have been outsourced (administration services, human resources activities, telecommunications, catering services, customer service, security, logistics, etc.) (Greaver, 1999; Jharkharia & Shankar, 2007). The Out-sourcing of materials, services and components has been recognized as a source of competitive advantage in as far as it aims at a higher value for the organization (Gupta & Zhender, 1994; Han, Lee, & Seo, 2008; Jennigs, 1997; Quinn & Hilmer, 1994).

Indeed, there are more compelling reasons for information professionals to take another look at Out-sourcing, as it can help an organization fulfill its mission. Out-sourcing, once used mainly for "recovery-oriented" purposes, such as downsizing and cost reduction at major corporations, is now becoming a growth-oriented strategic tool that has a powerful impact on future corporate innovativeness and profitability (Ozanne, 1997). This is all the more true now as firms establish strategic partnerships through syndication in the e-business arena to gain access to specialized expertise and highly focused and customized information content (Werbach, 2000).

Espino-Rodriquez and Padron-Robaina (2004) indicate that tactical Out-sourcing is basically carried out for motives of cost, while strategic Out-sourcing takes other aspects into consideration. These include achieving improved quality operations, unavailability of resources and ability to develop activities and/or to access capabilities and knowledge. Strategic Out-sourcing, therefore, is a broader, more complete conception of the process.

According to the Out-sourcing Institute, information technology is the business function most likely to be outsourced. Goo, Kishore, and Rao (2000) similarly state that even companies like Dupont and British Petroleum, with well-run and innovative IS departments large enough to accrue the same scale and specialization benefits as an IT vendor, are nevertheless engaged in IT Out-sourcing. They seem to use Out-sourcing to gain access to the capabilities and skills necessary to realize the potential of new and novel information. It can be seen, therefore, that Out-sourcing has become an alternative to In-sourcing, which all major corporations must consider in order to remain competitive and flexible.

2.1.3. Co-sourcing

The third means of reaping some of the benefits of synergies and leveraging replicable solutions to task assignment besides Out-sourcing and In-sourcing for the IT department is Co-sourcing. The concept of Co-sourcing can be defined best as putting together a group of service providers who are all working toward achieving one common goal (Borman, 2006). Co-sourcing, which represents a close partnership between the management function and the service provider is ideal for areas that are particularly strategic in nature and require regular client input. Here, bringing multiple service providers together to provide a comprehensive solution for the IT department saves money, time, and effort needed to obtain the necessary resources, which ultimately leads to operational efficiencies.

In a co-sourced environment, the IT department contracts with an outsourced firm to provide part of the IT solution, while the IT department handles the rest. Thus, internal organization has the higher degree of hierarchical control over the project (Kishore, Agrawal, & Rao, 2004). Although Co-sourcing is simply sharing the functions in the most efficient manner to capitalize on specific strengths and augment areas of weakness, its support service can help the IT department to bring this ideal to reality. By Co-sourcing, the IT department gains access to more advanced technology than it might be able to experience or maintain if all the services were kept in-house.

To be specific, the benefits to the IT department of Co-sourcing include ability to redirect efforts toward higher-value tasks, expanded skill, increased research capacity, and access to specialized expertise and resources. Improving operational efficiencies by leveraging the service provider's investment in technology, market data, and specialized capabilities that would be expensive to duplicate internally or are needed only during peak periods or for special projects, moreover, is not only highly beneficial in strategic terms, but also brings the IT department both flexibility and an opportunity to improve service, manage a variable cost structure, and scale its service capacity to meet changing business needs.

A feasible Co-sourcing arrangement is a promising new alternative for effective operational management since Co-sourcing's inherent flexibility allows an organization to scale resources up or down according to business requirements. Simultaneously delivering service control alongside the cost benefits associated with Out-sourcing, Co-sourcing enables organizations to scale IT support up or down in line with business needs, ensuring guaranteed service levels. In addition, Co-sourcing differs from In-sourcing in that it allows the outsourcing of activities that are essential to the company but are not core competencies, leading to medium or long-term cooperation with the supplier (Jennigs, 1997). Enjoying a strong partnership with the service provider, therefore, the client retains the power of strategic decision making, including that regarding technology refresh, policy definition and architecture issues, IT strategy, etc. – while the service provider takes over the day-to-day running of IT operations and provides recommendations on strategic aspects.

2.2. The factors of IS sourcing

The scan of the previous literature of operations strategy and management that were prevalent during the 1990s, the typical drivers of are cost savings, efficiency gains, improved quality or flexibility, etc. (Adam & Swamidass, 1989; Davis et al., 1999; Hayes & Wheelwright, 1984; Janssen & Joha, 2006; Leong, Snyder, & Ward, 1990; Skinner, 1969). Espino-Rodriquez and Padron-Robaina (2004) stated that the competitive advantages of leadership in cost or in differentiation may be achieved by attaining the objectives of operations management. The traditional criteria for evaluation in sourcing decisions, moreover, take the minimum cost or the maximum benefit as their single indicator, although these approaches may not be sufficient for the now increasingly complex and diversified decision-making environment. The motives for sourcing, have changed in this era of "Internet time", and now include issues concerning operations objectives, such as competitiveness, access to cash, time to market, innovativeness, round-the-clock customer service, agility, and access to world-class technology and skills. These motives for sourcing give companies different strategic advantages to the operations strategy and management, since they must pursue different competitive priorities simultaneously in order to succeed (Ferdows & De Meyer, 1990; Johnston et al., 1993). Other researchers argued that the IT department can enhance productivity and improve quality by Out-sourcing the IS function (McFarlan & Nolan, 1995; Perry & Devinney, 1997).

In order to adequately evaluate the sourcing decision, we considered critical criteria from various points of view on the basis of reviews of literature regarding optimal operations strategy and management. We also considered available strategies from task assignment and project management to validate the meaning of sustainable sourcing management. Furthermore, since different organizations should have different considerations on strategy or objectives of operations managements, the IT department should include all factors which might affect organizational benefit. On the basis of factors for evaluating alternatives, i.e., optimal operations strategy and management of IT department in this study, here, authors illustrate five factors with respect to the aspects which we consider of perspectives in achieving its setting goal in higher level of hierarchical system and combine a wide range of criteria as the following five major evaluation principles. These five major evaluation principles are task attribute, economic incentive, service quality, technological concerns and management issues. We excerpt two aspects for evaluating the task attribute, including the nature (NA) and the resource requirements (RR) of the task itself. We considered product cost (PC) and transaction cost (TC) in evaluating economic incentive, content enrichment (Enri.C.), and service level enhancement (Enha.S.L.) for evaluating service quality, and new technology acquisition (GainT) and technological innovation (Innov.T) with regard to technological concerns. Lastly, we considered integration (Imgmt), flexibility (Fmgmt), security and risk control (Srisk) for the evaluation of management issues.

2.2.1. Task attribute

The major considerations to keep IT functions in-house or contract with a third-party service provider are based on the nature (NA) and resource requirement (RR) of task itself. Firstly, the nature of task is meant to its core competency and value-added activities with the scale of economics. Thus, IT department may need to identify its core competency and distinguish its value-added activities because the organization has invested in the hardware, software and human resources, so the costs can be reduced and its operational result is more possible to reach the necessary operational scale and effectiveness of economics. Secondly, it may also need to focus on certain activities with strategic importance which enable drives some strategic implication for future need of growing in order to obtain competitive advantage and operational effectiveness. More importantly, the IT department may have a better management skill as well as higher productivity of human resource than outsider on the project. Depending on the value of such assets or competency, the decision maker is inclined to keep these activities or competency in house rather than outsource the operations because of desired significant operational efficiency.

On the other hand, another consideration of the task attribute is its resource requirement of the task itself. By outsourcing to specialist organizations services not generated by core competencies, companies can see an improvement in their organizational performance (Barthelemy & Geyer, 2005; Bettis, Bradley, & Hamel, 1992; Kotabe, 1989). The advantages of the Out-sourcing to the operations strategy and management are going to exert a positive influence on the organization's financial and non-financial performance. This is because it gives access to complementary resources of a higher quality and at a lower cost than if the company carried them out itself. Thus, the Out-sourcing of services of low strategic value enables the company to reduce costs and improve its competitive position (Gilley & Rasheed, 2000). Companies also can focus on what they do well and improve the resources and capabilities at their disposal. Certainly, researchers encourage organizations to think of themselves as a collection of services that provide value on the basis of an analysis of its nature and resource requirement of task (Quinn, Doorley, & Paquette, 1990). Finally, in line with the above reasoning, we establish two evaluation principles to assess task attribute that can influence the sourcing decision on the objectives of the operations management, that is, the nature (NA) and its resource requirement (RR) of task itself.

2.2.2. Economic incentive

The exchange of organizational skills and routines between the company and a specialist organization, and the joint use of capabilities, can give some advantages to the company through the potential to generate additional rents (Chi, 1994). One of the benefits of the exchange is cost efficiency (Jennigs, 1997). Williamson (1979) proposed that organizations have two principles when faced with a sourcing decision concerning economic incentive for value exchange between companies: production costs and transaction costs. Although, in practice, production and transaction costs are often difficult to assess, the framework created by Williamson for categorizing the most efficient decision mechanism provides a heuristic aid for estimating costs on the basis of the nature of the transaction. Generally speaking, production costs are lower with Out-sourcing because of vendor economies of scale achieved through mass production efficiencies and labor specialization. Mass production is assumed to reduce average costs by allocating fixed costs over more units of output and by receiving volume discounts on inputs. Labor specialization is assumed to reduce costs by allowing workers to focus on tasks at which they are most adept. Williamson, however, also argues that transaction costs are lower with In-sourcing since organizations find it less costly to coordinate, monitor, control, and manage internal employees than external vendors. In order for the inherent efficiencies of Out-sourcing or In-sourcing and even Co-sourcing to be realized, therefore, it is recommended that product cost (PC) and transaction costs (TC) be considered.

2.2.3. Service quality

Following that argument, economic incentive must not be the only consideration of sourcing decision; there must also be an improvement in quality. Most CIOs believe that there should be a significant difference between the quality of service provided by the Out-sourcing vendors and that of which the internal IS department (Gupta & Gupta, 1992) would be capable.

Quality is an objective that enables the IT department's operations to be improved in an organization. From the users' point of view, quality means obtaining a product or service that meets their needs, while the IT department sees it as meeting specifications and doing things well the first time (Garvin, 1998). If the IT department chooses to outsource its processes, it recognizes that there are companies in the market capable of carrying out part of its operations better than it can itself.

In many cases, the external supplier's capabilities include a specialized knowledge of the industry resulting from working with many clients. The external supplier's knowledge can be transferred to the internal IT department opting for Out-sourcing, since, the former's abilities, processes or technology will be especially able to satisfy the needs of the end user in the organization (Johnson, 1997). Those aspects have led to outsourced services of a quality higher than could have been achieved in-house and which therefore influence the end users' perception of quality to the organization. Content enrichment and good quality of service are nevertheless significant factors in the success of IT sourcing (Grover, Cheon, & Teng, 1996). To ensure high reliability and excellent performance of IS and good service quality, the IT department must establish performance goals and service levels in considering IT sourcing alternatives.

In line with the above reasons, the IT department will be more capability of telling by which sourcing mode they can pursue most improvement of the quality or enrichment of content to their operations management. Therefore, content enrichment (Enri.C.) and service level enhancement (Enha.S.L.) will be better to put them forward in the evaluation principles of sourcing decision.

2.2.4. Technological concerns

In the world of information technology, new technology acquisition (GainT) and advanced technology innovation (Innov.T) are very important and are highly expected because companies are able not only to improve service and operations efficiency but also to sustain competitive technological advantage. In addition, information technology research and development costs are incurred to fuel the development of new technologies. Only a few internal information technology departments, however, have the critical mass to justify large expenditures in research and development. Consequently, the fastest and most effective way to get the newest IT technology is to outsource. IS outsourcing allows management to focus available IS talent on important and strategic IT applications rather than on mundane and routine activities. On the other hand, the cost of acquiring technical expertise is also a major information technology cost driver, particularly for emerging technologies. Almost all clients or participants perceive that vendors have a cost advantage as far as technical expertise is concerned because vendors invest more capital and labor in developing new technologies than internal information technology departments.

It can be seen, therefore, that internal technological innovation and external new technology acquisition should work in union, striving to optimize flexibility, economies of scale and internal needs, and minimize unnecessary capital investment. Firms may also forge strategic alliances with vendors to make up shortfalls in technology. From strategic alliances, the firm may even develop and acquire new technology. Other strategic considerations include that in-house workers may learn new IS management technology from the vendor.

2.2.5. Management issues

As is well known, sourcing management has been regarded by senior managers as an effective means of strategic operations since effective sourcing management can improve performance, enhance resource integration and facilitate technology innovation by the IS department through sourcing configuration and management. For instance, Out-sourcing non-essential processes enables the organization to direct more managerial attention to the tasks it can do well while entrusting those that can be done better by a supply company to management by other companies. Blumberg (1998) states that Out-sourcing frees time for management to devote to priorities of a strategic nature and so have resources available for other purposes, giving greater flexibility in operations. The IT department, therefore, may outsource activities that do not fall within their core competencies, resulting in increased attention to their strategic activities.

For management issues, three aspects for achieving effective management are considered while considering the sourcing decisions in the previous literatures, which include integration (Curtis, Kellner, & Over, 1992; Tan & Harket, 1999), flexibility (Coe, 2000; Kotabe & Murray, 1990), and security and risk control (Clark, Zmud, & McCray, 1995).

2.2.5.1. For integration (Imgmt). Since IT work involves complex technology, information elements, and unique expertise of interface integration, it is important that the result of any execution of task not be a collection of incompatible systems or wasteful processes in the IT framework or at the value chain of any business process (Curtis et al., 1992). Tan and Harket (1999) indicated that efficient task integration requires a unique capability to enable each individual task within a process to remain integral and adequate, and the interactions between the workflows in multiple interacting processes to remain effective, even if the processes may be instantiated as distributed workflows. In order, therefore, to remove inefficiencies as well as to enhance manageability, a tended to be integrated project between disparate task and functional units through the whole project should be considered in sourcing decision while decisions are taken about task arrangement. Besides, the IT department also has to exploit the competitive advantage of in-house developed know-how to achieve productivity improvements by integrating disparate IT systems and deliver it services to meet existing and future business needs.

2.2.5.2. For flexibility (Fmgmt). Flexibility refers to the ability to respond to changes and to the degree of adaptability adopted when facing changing circumstances. This is true in information technology, since, once new technologies appear both the human and technological environment will change immediately. This ever changing environment has caused many organizations to reduce their size, as well as their degree of vertical integration, and focus on their main business or core competencies; in other words, they outsource secondary services.

Another consideration of incentive is financial flexibility. In Out-sourcing, facilities and employees are transferred to the vendor, which transforms fixed costs into variable costs, resulting in increasing financial flexibility. Furthermore, low or irregular demand may cause the in-house supply of services to be inefficient and unfeasible (Coe, 2000), while Out-sourcing can give greater flexibility to the internal operations of an organization. It should also be kept in mind that high levels of Out-sourcing are linked to a higher concentration of core competencies (Kotabe & Murray, 1990). A successful and exact sourcing decision, therefore, will make operational management of organizations more flexible, more dynamic, and better able to face the changes and opportunities that appear.

2.2.5.3. For security and risk control (Srisk). Other strategic considerations affecting the sourcing decision are those of security versus risk control (Clark et al., 1995). Generally speaking, a sourcing decision is rare to experience opportunities where the managerial actions taken to generate benefits are not associated with potential risks either. Operational security and risk control is a critical issue confronting senior IT executives pursuing effective management of the IT task assignment. In the Dataquest survey, 5.8% of the respondents cite "sharing the risk" as an advantage (Schwartz, 1992). Thirty-one percent, however, cite "loss of control" over the quality of IS services as a disadvantage of Out-sourcing. Proprietary data issues represent a large risk to the company that decides to outsource. Thus, a good sourcing decision therefore must take security and risk into serious consideration.

Consequently, for the above reasons, we put forward integration, flexibility, and security and risk control to be some of the evaluation principles of sourcing decision with regard to the management issues.

3. An integrated IS sourcing model for the operations strategy and management

In today's information-intensive economy IT plays a pivotal role not only in enabling firms to achieve operational excellence, but also in facilitating strategic competitive advantage (Ferratt, Agarwal, Brown, & Moore, 2005; Neirotti & Paolucci, 2007). In order to meet rapidly changing technology trends with low costs and high quality, companies tend to rely on external vendors and contractors to manage and maintain their information systems. Scholarly and practitioner articles in information system research, however, have argued that out-sourcing may not be a panacea for all IS performance problems, and have advocated selective In-sourcing or Co-sourcing (William & Yogesh, 1999). There is a clear need for a framework for further analyzing IS sourcing if operations strategy and management in relation to IT projects are to be optimized.

3.1. The methodology of the research

Generally speaking, a project can be made up of several tasks. The main issue of this study is to decide the priority of sourcing mode to execute IS task by which sourcing mode the goal of optimal operations strategy and management will be carried out and achieved in the project.

The IS sourcing criteria of operations strategy and management, as presented above, all essentially follow a one-way linear approach. Also, there is a network structure with an interdependent relationship of feedback between perspectives, criteria and alternatives. These "causal chains" contain outcome measures and their operations performance drivers, linked together in assumed cause and effect relationships. Weber, Werners, and Zimmerman (1990) stated that many real-world problems have an interdependent property among the perspectives, criteria or candidate projects. And an interdependent property IS problem, basically, can be classified into three types: (1) technical interdependencies, (2) resource interdependencies, and (3) benefit interdependencies. Lee and Kim (2001) also pointed out that IS project selection / task arrangement problems are Multi-Criteria Decision Making (MCDM) problems, and that the criteria for MCDM can include quantitative and qualitative factors, but the quantitative criteria may be measured in incomparable units. Economic incentive criteria and other criteria mentioned in this study – such as task attribute, technology concern and service quality, which are less easy to quantify – therefore, all need to be considered equally. Here, DEMATEL, ANP and ZOGP are the main quantifying methods of MCDM problems.

We therefore propose the following quantitative decision model, combining the DEMATEL, ANP and ZOGP methods with a view to achieving effective problem-solving. This integrated model will not only construct a network structure of ANP for IT sourcing strategy mix decisions and address the relationship between sourcing decision criteria, but also find an optimal sourcing portfolio for execution of the project and attain the objectives of an organization in accordance with the operations strategy and management while allowing for restricted resources.

3.2. The evaluation process of the research

To better look insight the relationships of a network structure with relation to evaluation principles, author can be easy to evaluate and conclude the degree of interdependence by using the calculation tools of DEMATEL. The DEMATEL model, therefore, could be one of the tools for formalizing such relations. Such well-formalized relations will then be integrated into the ANP to construct an IS sourcing decision model and obtain the weights of each perspective, criteria and potential sourcing alternative for each task of the project conforming to the evaluation principles of the operations strategy and management.

Appendix A summarizes some definitions and properties of DEMATEL. The DEMATEL, used to research and solve complicated and intertwined problems, has been successfully applied in many fields, such as marketing strategies, R&D projects, e-learning evaluation, managers' competencies, control systems, airline safety problems, corporate social responsibility programs, and so on (Chiu, Chen, Tzeng, & Shyu, 2006; Liou, Tzeng, & Chang, 2009; Tsai & Chou, 2009; Tsai, Chou, & Hsu, 2009; Tsai & Hsu, 2008; Tzeng, Chiang, & Li, 2007; Wu & Lee, 2007a).

Lee and Kim (2000) stated that the ANP method may transform qualitative judgments into quantitative values, and is more appropriate for making strategic decisions. This method has so far been applied in a variety of academic fields, such as project selection (Aragones-Beltran, Aznar, Ferrıs-Onate, & Garcıa-Melon, 2008; Meade & Presley, 2002), production planning (Karsak, Sozer, & Alptekin, 2002; Lin, Chiu, & Tsai, 2008; Meade & Sarkis, 1999), and strategic decisions (Leung, Lam, & Cao, 2006; Wu & Lee, 2007b). Here, ANP that consider the interdependence effect among criteria will be used to evaluate the weights of each potential sourcing mode for each task of the project, no matter how many tasks will be involved in the model. The result of the weights for each task will not only be thought of as a preference for IS task arrangement but also be deployed as a constrained condition in the following ZOGP model. It is worth emphasizing that the ANP method can not only conclude the priorities but also present the weight (importance) for the selection of sourcing modes or task arrangement. The information obtained from the ANP will, then, affect the arrangement of the finite resources use in the organization at the end. Appendix B summarizes some definitions and properties of ANP.

Eventually, the method of zero-one goal programming (ZOGP) will be employed to find the optimal task sourcing portfolio for the project and to attain the objectives of an organization while considering restricted resources (Mathirajan & Ramanathan, 2007). Goal programming (GP) was first introduced by Charnes, Cooper, and Ferguson (1995). The method has been applied in a variety of ranked resource selection schemes (Çekyay, Gümüssoy, & Ertay, 2005; Chen & Shyu, 2006; Lee & Kim, 2000; Mathirajan & Ramanathan, 2007; Schniederjans & Wilson, 1991). Chen and Shyu (2006) mentioned that the model of ZOGP can assign optimal values to a set of variables in situations involving multiple and conflicting goals. Lee and Kim (2000) stated that ZOGP permits the consideration of resource limitations and other selection limitations that must be rigidly observed in the project selection problems. Appendix C summarizes some definitions and properties of ZOGP.

With this integrated model of DEMATEL, ANP and ZOGP, an optimal task sourcing portfolio for the execution of the project will be found. The ZOGP model results, thus, provide an optimal recommendation that can help managers to decide the most appropriate sourcing mode to execute to each task of the project, that is, an optimal task sourcing portfolio for the project. The research process of the integrated MCDM model is shown in Fig. 1.

3.3. The structure of the research

Many studies have stressed the importance of aligning the IS planning process with the overall corporate strategy (MacDonald, 1991; Peak, Guynes, & Kroon, 2005; Powell, 1993). One reason the PM/business strategy alignment has become the focus of attention is that companies must develop and execute innovative operations strategy and management in order to stay competitive advantage and obtain operational effectiveness (Srivanaboon & Milosevic, 2006). Moreover, authors devise task portfolio management to enhance the business strategy alignment in the research process of the integrated MCDM model. Here, task portfolio management is the process that links the mission, objectives and strategy of the project to the execution of individual project tasks. Task portfolio management represents the tactical level, where decisions are made about what sourcing mode to carry out the task in highly support of the company's mission, objectives, and strategy.

To ensure that sourcing decision mode is actually being implemented by each task of the project, the delegated expert panel could put the policies and principles of business strategy alignment and task portfolio management and put them onto the sourcing criteria of optimal operations strategy and management. Executive decision makers, subsequently, may apply these sourcing criteria

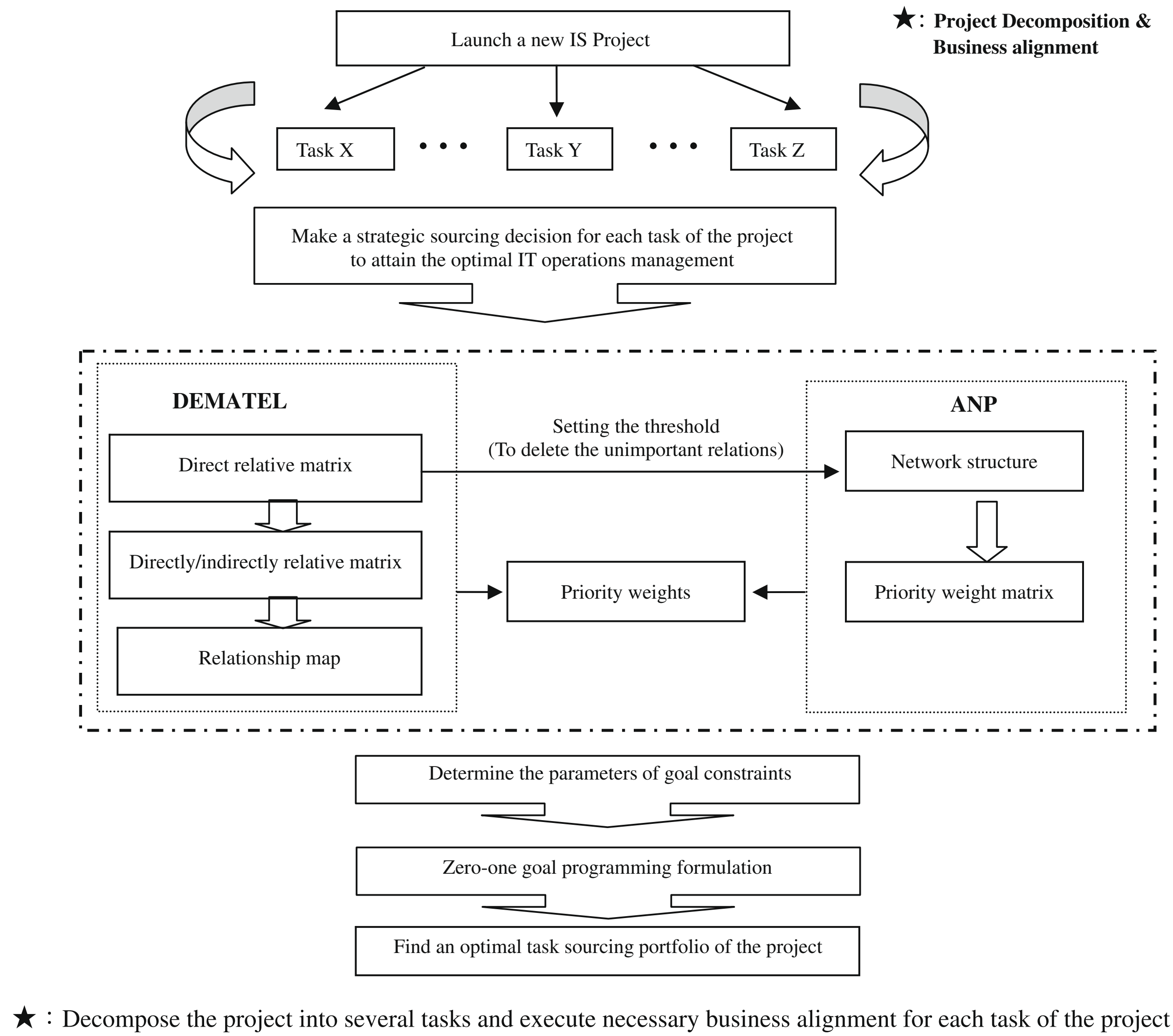

Fig. 1. A process overview of the integrated MCDM model in task sourcing decision.

to evaluate and select a more appropriate sourcing mode for task execution to each task of the project. This fully designed framework, therefore, provides an opportunity for executive management to fulfill overall IT infrastructure of the institute in the upper or strategic level according to mission and objectives of the organization when making sourcing decisions. And the final sourcing decision could be presented in the outcomes of an optimal task sourcing portfolio for task execution of the project at the end of the calculation in ZOGP model according to the priorities specified.

4. An illustrative application of IS sourcing strategy mix decisions

The following case gives a specific example of how an optimal project task sourcing portfolio can be pursued in accordance with the goal and criteria of operations strategy and management and the limitation of finite resources through the proposed tools of the integrated IS sourcing model.

4.1. Problem description

E. Sun Commercial Bank is a leader in the financial services industry in Taiwan. By combining the latest technology with top-notch service, E. Sun Commercial Bank has since 1999 successfully developed electronic banking services with a suite of products besides its over-the-counter services. However, owing to related financial services those are still limited on the specific websites of its proprietary banks and their safe mechanisms that are involving various kinds of potential risks, on-line intrusion, hacker's Trojan procedure, etc., affecting consumer confidence, the image of banking and the tendency of use of their customers'.

To further improve the efficiency of banking operations and achieve steady development under the strategy of IT introduction and online service of penetration, E. Sun Commercial Bank has been ushered to launch a project to build a new and improved Internet Banking and bill payment system – called a WebATM system – giving customers constant access to account information, up-to-the-minute financial control and transaction security. This project is expected to make Internet banking and bill payment more efficient than ever, with easy-to-understand screens, user-friendly navigation and added functionality, and enabling customers to carry out elementary transactions such as inter-bank account transfers, bill payments, tax payments, and balance inquiries. E. Sun Commercial Bank, however, has always struggled with its IT strategies, which present unique technological challenges and roadblocks that tend to center on flexibility, control and scalability.

Assume that E. Sun Commercial Bank can locate suitable service vendors providing the necessary service and the latest IS solutions with the explicit cost structure analysis and that it is certain, after reviewing the market, that there are no differences between the available services and solutions. Assume also that this project for building a WebATM system normally involves at least three main tasks which E. Sun Commercial Bank should kick off an Internet homepage system on original electronic banking services system, embed an online transaction processing system and develop the customer relationship management system.

In its effort to meet the needs of the operations strategy and management, E. Sun Commercial Bank has difficulty identifying and making the necessary sourcing decisions among the potential sourcing alternatives under the authority of project budget even though all they have been done full examination thought the cost-benefit analysis. For handling this MCDM problem of task arrangement, assume E. Sun Commercial Bank adopts our proposed method and sets up an expert panel. The following evaluation process shows how the bank utilizes our proposed method to decide logically on an optimal task sourcing portfolio for each task execution of the project.

4.2. Applications of the proposed method

4.2.1. Constructing decision making structure of IS sourcing

Following the case scenario, an evaluation model can be developed for constructing an IS sourcing decision hierarchy. A typical ANP hierarchy consists of at least three levels: the goal, the evaluation criteria and the alternatives.

The highest level with only one element is the ultimate goal of the decision maker(s). In this study, the goal of the ANP model is to make sourcing decisions for each task of the project to attain the optimal operations strategy and management, and is placed at the first level of the hierarchy. The second level of the ANP model is the factors of the perspectives and criteria for achieving the goal. In the IS sourcing consideration, perspectives and criteria mean those factors of evaluation principles that conform to of operations strategy and management are built up by the expert panel as mentioned in Section 2.2. Lastly, the final level of the structure is the sourcing alternatives. We consider three aspects of potential IS sourcing modes as the alternatives of task arrangement, including In-sourcing, Co-sourcing and Out-sourcing. That is, the expert panel will evaluate and assign the weights to each potential alternative for the execution of the task of the project individually, in accordance with the perspectives and criteria of the operations strategy and management. The overview of the ANP structure is shown in Fig. 2.

In particular, such well-constructed evaluation process of sourcing decision model could be extended and applied to any existing or future tasks, projects or systems that need access to both internal and external resources and fit in with the goals of operations strategy and management simultaneously. This proposed decision model to the sourcing mode could therefore be a dynamic decision model of sourcing arrangement and will conform more close to the decision need for the practitioners in reality.

4.2.2. Evaluating relationships between perspectives by DEMATEL

Before the IS sourcing decision hierarchy of ANP is applied to obtain the weights of each potential sourcing alternative for each task of the project, the causal relationships of the perspectives and criteria involved should be analyzed and evaluated for further application of ANP in order to identify their direct, indirect and total influences among the cause and effect groups. Following the procedure of the DEMATEL method, the expert panel will be asked to determine the intensity of the influence between each perspective and criterion through the use of scale and pairwise comparisons. Once the relationships between those factors have been measured by the expert panel, the initial direct-relation and the normalized direct-relation matrix can be produced. Then the total-relation matrix by using formula (A.3) and the impact-diagraph-map can be acquired by mapping a dataset of $(D+R, D-R)$. These are shown in Tables 1 and 2 for perspectives and criteria, respectively.

Here, the expert panel has to choose an appropriate value as a threshold in order to focus on those perspectives and criteria that provide great influence, and not to blur in the network structure of the whole system because of too many factors. Threshold values of 0.1 and 0.16 are, thus,chosen as a threshold to the perspectives and criteria respectively after consulting with the expert panel. Each of the two numbers is the most appropriate value for acquiring a suitable relationship from trying above and under this number. The impact relations maps of the DEMATEL method are presented in Figs. 3 and 4. Meanwhile, it should be emphasized that factors with high $(D+R)$ values that play a central role, and factors with high $(D-R)$ value that mainly dispatch influence to other factors. And so forth, factors with low $(D-R)$ value that mainly receive influence from the other factors.

As we can see in Fig. 3, the evaluation of the perspectives are visually divided into the dispatcher group which is based on the threshold value of 0.1, and comprising task attribute, technology concern and management concern, while the receiver group is composed of such factors as service quality and economic incentive. This is to say that task attribute, technology concern and management concern will exert a great influence upon the final service quality and economic incentive for IS sourcing. Similarly, it is quite obviously that TA, RR, GainT, Innov.T will result in Enri.C., Enha.S.L. and production and transaction cost (PC&TC) of the criteria based on the threshold value of 0.16 in Fig. 4.

Subsequently, the expert panel deploys both of the well-formalized relations of the perspectives and criteria into ANP model to construct a complete IS sourcing decision model.

4.2.3. Set priority weight by ANP

After the relationship structure systems of the perspectives and the criteria have been formulated and set in the IS sourcing decision hierarchy, the ANP approach is applied to derive the weights of each potential sourcing alternative for each task of the project.

For determining the relative importance between elements, the expert panel was asked to provide their subjective value judgments through a series of pairwise comparisons. Each comparison score was collected on the basis of Saaty's nine-point scale, where a score of 1–9 are of equal importance and the extreme importance of one factor over another. Meanwhile, the consistency ratio (C.R.) values are required under 0.1 for each node comparison. Here Super Decisions 1.6.0 software was applied to aid calculation and calculate the weights.

On the basis of the assessments of the expert panel, the values associated with the unweighted supermatrix M for each task of the case project are shown in Tables 3–5. Not all of the individual columns, however, sums to one in the unweighted supermatrix. That is because there are interactions between the clusters. In order to minimize the possibility for divergence to infinity or convergence to zero, a transformation is required for the columns to become column-stochastic. The transformation process is to weight the components according to their impact on the column of blocks. In this case, the expert panel firstly assumed the two column block weightings for the "Goal" column to be a 0.50 weighting for the "Goal" column block and 0.50 for the "Perspectives" column block. Then, the two column block weights "perspectives" and "Criteria" for the "perspectives" column were assumed to be 0.50 and 0.50, respectively. Once again, assuming the two column block weights "Criteria" and "Alternatives" for the "Criteria" column are

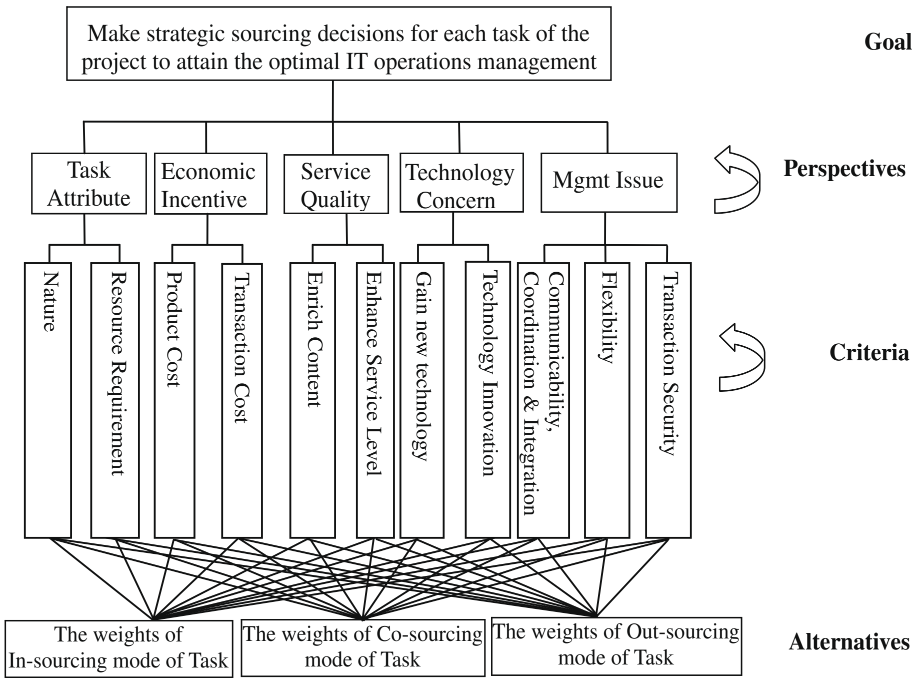

Fig. 2. The hierarchical framework of factors.

Table 1
The total-relation matrix for perspectives ($p \geqslant 0.1$).

	Task attribute	Economic incentive	Service quality	Technology concern	Mgmt issue	D	$D+R$	$D-R$
Task attribute	0.000	**0.434**	**0.212**	**0.191**	**0.254**	1.091	1.091	1.091
Economic incentive	0.000	0.000	0.000	0.000	0.000	0.000	1.400	−1.400
Service quality	0.000	**0.278**	0.025	0.014	0.095	0.413	1.117	−0.292
Technology concern	0.000	**0.301**	**0.189**	0.021	**0.141**	0.653	1.038	0.267
Mgmt issue	0.000	**0.386**	**0.278**	**0.159**	0.045	0.868	1.402	0.333
R	0.000	1.400	0.705	0.385	0.535	3.024		

Table 2
The total-relation matrix for criteria ($p \geqslant 0.16$).

	NA	RR	PC	TC	Enri.C.	Enha.S.L.	GainT	Innov.T	Imgmt	Fmgmt	Srisk	D	$D+R$	$D-R$
NA	0.037	**0.167**	**0.298**	**0.198**	**0.170**	**0.186**	0.140	**0.161**	**0.246**	0.148	**0.231**	1.983	2.276	1.690
RR	**0.162**	0.032	**0.217**	**0.286**	**0.168**	**0.179**	0.138	**0.164**	**0.240**	**0.229**	0.146	1.961	2.254	1.668
PC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.763	−1.763
TC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.542	−1.542
Enri.C.	0.004	0.004	0.143	0.085	0.032	0.127	0.014	0.019	0.072	0.071	0.071	0.642	1.742	−0.459
Enha.S.L.	0.004	**0.004**	0.143	0.085	0.123	0.036	0.014	0.019	0.072	0.071	0.071	0.642	1.889	−0.606
GainT	**0.006**	0.006	**0.198**	**0.214**	0.131	0.140	0.020	0.128	0.105	0.105	0.105	1.157	1.747	0.568
Innov.T	0.004	**0.004**	**0.197**	0.154	0.082	0.116	0.014	0.019	0.074	0.074	0.074	0.813	1.661	−0.035
Imgmt	0.009	0.009	**0.207**	**0.232**	**0.192**	**0.203**	0.105	0.122	0.058	0.148	0.148	1.431	2.532	0.330
Fmgmt	0.005	0.005	**0.212**	0.153	0.088	0.095	0.063	0.121	0.080	0.032	0.080	0.934	1.917	−0.049
Srisk	0.062	0.062	0.148	0.136	0.115	**0.166**	0.081	0.095	0.154	0.105	0.057	1.182	2.165	0.198
R	0.293	0.293	1.763	1.542	1.101	1.247	0.590	0.848	1.101	0.983	0.983	10.745		

multiplied in turn by 0.50, respectively. Finally, the component block weights were multiplied to each of the respective column elements.

After the weighted supermatrices were adjusted and obtained, they could be raised to limiting powers to catch all the interactions and to obtain a steady-state outcome. The overall results revealed that the task with the highest weight for kicking off an Internet homepage system is recommended to adopt the In-sourcing mode; the task to embed an online transaction processing system is recommended to adopt the Out-sourcing mode; the task to develop a CRM system is recommended to adopt the Co-sourcing mode.

The final ANP weights represent a set of priority of the sourcing modes by which priority IS task could be in turn arranged and executed based on the recommendation of the expert panel. That is to say that each task of the case project on the phase of ANP will be suggested a set of priority of sourcing mode to execute, respectively, in accordance with the goal of operations strategy and management of an organization. And this priority of sourcing mode is fully with the company's strategic direction. Consequently, the goal of operations strategy and management of an organization could be carried out on the task arrangement. The ANP weights of sourcing mode for each task of the case project are shown as following:

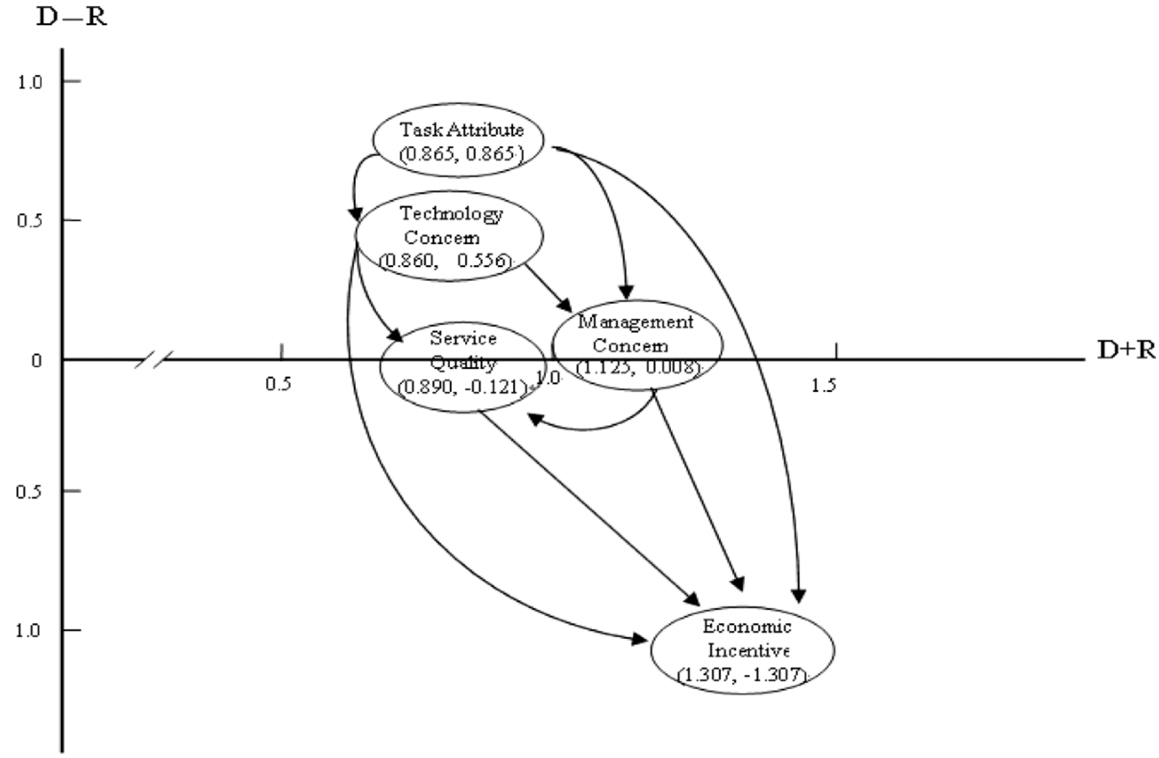

Fig. 3. The impact-digraph-map of total-relation – for perspectives ($p \geqslant 0.1$).

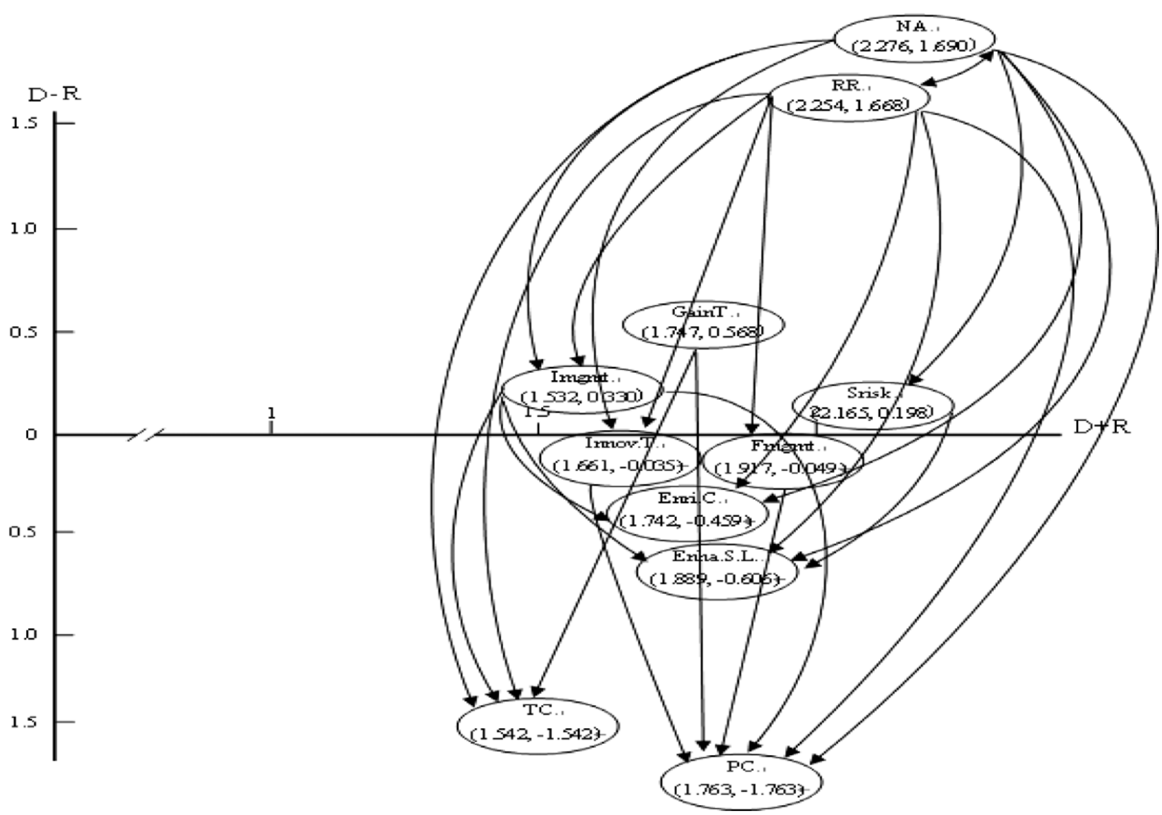

Fig. 4. The impact-digraph-map of total-relation – for criteria ($p \geqslant 0.16$).

Table 3
The unweighted supermatrix, *M* for the task of the Internet homepage system (Homepage).

		Goal	Perspectives					Criteria											Alternatives		
		OSOM	Task	Econ.	SQ	Tech	Mgmt	NA	RR	PC	TC	Enri.C.	Enha.S.L.	GainT	Innov.T	Imgmt	Fmgmt	[illegible]	Insour.	Cosour.	Outsour.
Goal	1OSOM	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000
Perspectives	Task	0.4710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Econ.	0.1425	0.2751	0.0000	0.5000	0.2857	0.5714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SQ	0.0751	0.1376	0.0000	0.0000	0.1429	0.2857	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Tech	0.0437	0.0741	0.0000	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Mgmt	0.2677	0.5132	0.0000	0.5000	0.5714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Criteria	NA	0.0000	0.8000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3667	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	RR	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.2607	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	PC	0.0000	0.0000	0.6667	0.0000	0.0000	0.0000	0.2167	0.1716	0.0000	0.0000	0.0000	0.0000	0.5000	1.0000	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000
	TC	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0940	0.0868	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.2500	1.0000	0.0000	0.0000	0.0000	0.0000
	Enri.C.	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.0680	0.0512	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000
	Enha.S.L.	0.0000	0.0000	0.0000	0.6667	0.0000	0.0000	0.0976	0.0641	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	1.0000	0.0000	0.0000	0.0000
	GainT	0.0000	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Innov.T	0.0000	0.0000	0.0000	0.0000	0.6667	0.0000	0.0612	0.0765	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Imgmt	0.0000	0.0000	0.0000	0.0000	0.0000	0.5714	0.0811	0.0865	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Fmgmt	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.0000	0.0966	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Srisk	0.0000	0.0000	0.0000	0.0000	0.0000	0.2857	0.1208	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Alternatives	Insour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7071	0.6910	0.5396	0.7418	0.6833	0.5499	0.6833	0.5499	0.7306	0.5714	0.7418	1.0000	0.0000	0.0000
	Cosour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2227	0.2176	0.2970	0.1830	0.1998	0.2403	0.1998	0.2403	0.1884	0.2857	0.1830	0.0000	1.0000	0.0000
	Outsour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0702	0.0914	0.1634	0.0752	0.1169	0.2098	0.1169	0.2098	0.0810	0.1429	0.0752	0.0000	0.0000	1.0000

Table 4
The unweighted supermatrix, *M* for the task of the online transaction processing system (OLTS).

		Goal	Perspectives					Criteria											Alternatives		
		OSOM	Task	Econ.	SQ	Tech	Mgmt	NA	RR	PC	TC	Enri.C.	Enha.S.L.	GainT	Innov.T	Imgmt	Fmgmt	Srisk	Insour.	Cosour.	Outsour.
Goal	1OSOM	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Perspectives	Task	0.4710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Econ.	0.1425	0.2751	0.0000	0.5000	0.2857	0.5714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SQ	0.0751	0.1376	0.0000	0.0000	0.1429	0.2857	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Tech	0.0437	0.0741	0.0000	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Mgmt	0.2677	0.5132	0.0000	0.5000	0.5714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Criteria	NA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3032	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	RR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2603	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	PC	0.0000	0.0000	0.6667	0.0000	0.0000	0.0000	0.1652	0.2552	0.0000	0.0000	0.0000	0.0000	0.5000	1.0000	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000
	TC	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.7301	0.0786	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.2500	1.0000	0.0000	0.0000	0.0000	0.0000
	Enri.C.	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.5939	0.0451	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000
	Enha.S.L.	0.0000	0.0000	0.0000	0.6667	0.0000	0.0000	0.1051	0.0609	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	1.0000	0.0000	0.0000	0.0000
	GainT	0.0000	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Innov.T	0.0000	0.0000	0.0000	0.0000	0.6667	0.0000	0.1260	0.0787	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Imgmt	0.0000	0.0000	0.0000	0.0000	0.0000	0.5714	0.0849	0.0704	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Fmgmt	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.0000	0.1080	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Srisk	0.0000	0.0000	0.0000	0.0000	0.0000	0.2857	0.1266	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Alternatives	Insour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1095	0.0841	0.0890	0.1634	0.0733	0.1000	0.0623	0.0608	0.1634	0.0695	0.1634	1.0000	0.0000	0.0000
	Cosour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3090	0.2109	0.3234	0.2930	0.2559	0.3000	0.2851	0.3531	0.2930	0.3484	0.2930	0.0000	1.0000	0.0000
	Outsour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5816	0.7049	0.5876	0.5396	0.6708	0.6000	0.6527	0.5861	0.5396	0.5821	0.5396	0.0000	0.0000	1.0000

Table 5
The unweighted supermatrix, *M* for the task of the customer relationship management system (CRM).

		Goal	Perspectives					Criteria											Alternatives		
		OSOM	Task	Econ.	SQ	Tech	Mgmt	NA	RR	PC	TC	Enri.C.	Enha.S.L.	GainT	Innov.T	Imgmt	Fmgmt	Srisk	Insour.	Cosour.	Outsour.
Goal	1OSOM	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Perspectives	Task	0.4710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Econ.	0.1425	0.2751	0.0000	0.5000	0.2857	0.5714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SQ	0.0751	0.1376	0.0000	0.0000	0.1429	0.2857	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Tech	0.0437	0.0741	0.0000	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Mgmt	0.2677	0.5132	0.0000	0.5000	0.5714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Criteria	NA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3032	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	RR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2603	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	PC	0.0000	0.0000	0.6667	0.0000	0.0000	0.0000	0.1652	0.2552	0.0000	0.0000	0.0000	0.0000	0.5000	1.0000	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000
	TC	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0730	0.0786	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.2500	1.0000	0.0000	0.0000	0.0000	0.0000
	Enri.C.	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.0594	0.0451	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000
	Enha.S.L.	0.0000	0.0000	0.0000	0.6667	0.0000	0.0000	0.1051	0.0659	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	1.0000	0.0000	0.0000	0.0000
	GainT	0.0000	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Innov.T	0.0000	0.0000	0.0000	0.0000	0.6667	0.0000	0.1260	0.0787	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Imgmt	0.0000	0.0000	0.0000	0.0000	0.0000	0.5714	0.0849	0.0704	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Fmgmt	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.0000	0.1080	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Srisk	0.0000	0.0000	0.0000	0.0000	0.0000	0.2857	0.1260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Alternatives	Insour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2385	0.1095	0.1365	0.2385	0.0733	0.0695	0.0811	0.0974	0.0914	0.0695	0.5396	1.0000	0.0000	0.0000
	Cosour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6250	0.5816	0.6250	0.6250	0.2559	0.5821	0.3420	0.3331	0.6910	0.3484	0.2970	0.0000	1.0000	0.0000
	Outsour.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1365	0.3090	0.2385	0.1365	0.6708	0.3484	0.5769	0.5695	0.2176	0.5821	0.1634	0.0000	0.0000	1.0000

$$\text{ANP}_{\text{Homepage}} = \begin{pmatrix} \text{In-sourcing} \\ \text{Co-sourcing} \\ \text{Out-sourcing} \end{pmatrix} = \begin{pmatrix} 0.62874 \\ 0.24041 \\ 0.13086 \end{pmatrix};$$

$$\text{ANP}_{\text{OLTS}} = \begin{pmatrix} \text{In-sourcing} \\ \text{Co-sourcing} \\ \text{Out-sourcing} \end{pmatrix} = \begin{pmatrix} 0.11053 \\ 0.30518 \\ 0.58429 \end{pmatrix};$$

$$\text{ANP}_{\text{CRM}} = \begin{pmatrix} \text{In-sourcing} \\ \text{Co-sourcing} \\ \text{Out-sourcing} \end{pmatrix} = \begin{pmatrix} 0.17352 \\ 0.56422 \\ 0.26226 \end{pmatrix}$$

4.2.4. Find an optimal sourcing portfolio of IS project by using the Goal Programming Model

Although the expert panel suggested and provided a set of priority of the sourcing modes for each task of the project on the phase of the ANP, E. Sun Commercial Bank still had to make an optimal selection decision under the authority of project budget and related resource constraints of the organization. Thus, when the priority weights of sourcing alternatives of each task of the project have been ascertained, these ANP weights will not only be thought of as preferences for IS task arrangement but also be deployed as a constrained condition of goal programming in the ZOGP model.

Furthermore, performing a task/project will need to consume some internal resources, no matter which sourcing mode has been chosen. However, these involved resources to the organization normally are limited in the capacity of IT department. Here, tasks may be executed by different sourcing modes and may also be consumed at different level of IT resources of its organization. Thus, there exist several limitations to the available resources that must be considered in order to fulfill the final project deliverable. These consumptions of internal IT resources may normally involve and be counted by budget amount, programmer hours, and some training hours and so on. Table 6 illustrates by different sourcing mode some limitations and requirements for building a WebATM system: (1) total maximum of $ 1,110,000 for budget amounts; (2) total maximum of 6650 h for analyst hours; (3) total maximum of 13500 h of programmer time; (4) total maximum of 1130 hours of training time for the new system. Two flexible limitations exist. An initial budget allocation was set at $900,000, which could vary up to but not beyond the total maximum value of $1,110,000. Additionally, an initial allocation scheme for labor hours was set at 4000 h, but deviation from this allocation was permitted.

In Table 6, x_1, x_2 and x_3 represent the sourcing mode (In-sourcing, Co-sourcing and Out-sourcing) adopted by the task *X* of the case project, respectively. y_1, y_2 and y_3 represent the sourcing mode adopted by the task *Y* of the case project, respectively. z_1, z_2 and z_3 represent the sourcing mode adopted by the task *Z* of the case project, respectively. Eventually, ANP weights and ZOGP method are combined for the final IS sourcing mode selection to perform each task of the project in building a WebATM system under the limitations of organizational resources. According to the ANP priorities and organizational objectives and limitations, the final ZOGP model formulation is built in Table 7, where p represents the preemptive priority and d_i^+ and d_i^- are the negative and positive deviation variables, respectively. Meanwhile, x_j, y_j and z_j are the binary variable. x_j, y_j or $z_j = 1$ represents the jth sourcing mode was selected, and when x_j, y_j or $z_j = 0$ represents the jth sourcing mode was not selected respectively; a_{ij} represents the quantity of resources required for the jth sourcing mode; b_i is the constraint on the available resources. Certainly, only one sourcing mode will be accepted for each task of the project in the model.

The Lingo 10.0 software was used to solve the ZOGP model. The results were as follows:

$$x_1 = 1,\quad x_2 = 0,\quad x_3 = 0,\quad y_1 = 0,\quad y_2 = 1,\quad y_3 = 0,$$
$$z_1 = 0,\quad z_2 = 0,\quad z_3 = 1,\quad d_1^- = 4950,\quad d_1^+ = 0,\quad d_2^- = 2540,$$
$$d_2^+ = 0,\quad d_3^- = 4515,\quad d_3^+ = 0,\quad d_4^- = 3020,\quad d_4^+ = 0,$$
$$d_5^- = 0,\quad d_6^- = 1,\quad d_7^- = 1,\quad d_8^- = 1,\quad d_9^- = 0,\quad d_{10}^- = 1,$$
$$d_{11}^- = 1,\quad d_{12}^- = 1,\quad d_{13}^- = 0,\quad d_{14}^- = 1140,\quad d_{14}^+ = 0,$$
$$d_{15}^- = 0,\quad d_{15}^+ = 0$$

Generally speaking, the sourcing mode with the highest weights represented the most important degree to achieve organizational objectives and would be best adopted to execute the task in advance. After considering the obligatory and mandated limitations, as the result shows, it is not necessary that the sourcing mode with the highest weights should be adopted in advance by the task in every instance. The different ANP weights and limitations result in the different optimal solutions. Finally, the results show that this integrated MCDM support model can not only fully utilize the available resources of the organization but also find an optimal task sourcing portfolio for executing each task of the project in building a WebATM system.

5. Discussion

Constructing a framework for IT sourcing strategy mix decision is the focus of this integrated MCDM support model. By using the proposed decision support model in the IT sourcing decision making, the decision makers can systematically consider the interdependent relationships between the IS sourcing criteria of the operations strategy and management to obtain the optimal task arrangement for the project. Furthermore, through an iterative and interactive procedure of collecting the decision criteria, the common consensus of an organization can be ascertained. This model is not only good for gathering group opinions and reducing decision bias from a single or a few decision makers but also valuable for constructing an uncertain framework from an interdependent network structure. More importantly, the process can enhance the transparency of the evaluation and allows good argumentation in IT sourcing decision making. The processes presented in the case served as an integrated MCDM support model for gathering the opinions of the expert panel and considering the environmental limitations of the organization or requirements of the project. This paper can therefore show its contribution of the integrated MCDM support model to IT sourcing strategy mix decision

Table 6
The resource requirements to each task of the project by different sourcing mode.

	The resource requirements to each task of the project by different sourcing mode (a_{ij})									
	x_1	x_2	x_3	y_1	y_2	y_3	z_1	z_2	z_3	b_i
Budget amounts (1000 $)	$500	$310	$1125	$600	$410	$925	$600	$410	$1325	$6750
Programmer hours (h)	1250	600	200	750	500	120	1850	1200	1000	7700
Analyst hours (h)	650	760	950	340	400	620	250	300	450	4040
Training hours (h)	250	450	560	450	600	900	550	700	950	4820
Labor hours (h)	900	1100	1500	650	800	1200	1000	1200	1500	3200

Table 7
The ZOGP model formulation.

ZOGP model formulation	Goals
Minimize Z =	
$p_1(d_1^+ + d_2^+ + d_3^+ + d_4^+)$	Satisfying four mandated resources constraint of the project
$p_2(w_1 d_5^- + w_2 d_6^- + w_3 d_7^- + w_4 d_8^- + w_5 d_9^- + w_6 d_{10}^- + w_7 d_{11}^- + w_8 d_{12}^- + w_9 d_{13}^-)$	Selecting the largest weights by ANP priority weights
$p_3(d_{14}^+ + d_{14}^-)$	Using $3375 budget for all sourcing modes selection to the project
$p_4(d_{15}^+ + d_{15}^-)$	Using $3200 labor hours for all sourcing modes selection to the project
Subject to:	
$500x_1 + 310x_2 + 1125x_3 + 600y_1 + 410y_2 + 925y_3 + 600z_1 + 410z_2 + 1325z_3 - d_3^+ + d_3^- = 6750$	Avoiding over-utilizing maximum budgets amounts
$1250x_1 + 600x_2 + 200x_3 + 750y_1 + 500y_2 + 120y_3 + 1850z_1 + 1200z_2 + 1000z_3 - d_1^+ + d_1^- = 7700$	Avoiding over-utilizing maximum programmer hours
$650x_1 + 760x_2 + 950x_3 + 340y_1 + 400y_2 + 620y_3 + 250z_1 + 300z_2 + 450z_3 - d_2^+ + d_2^- = 4040$	Avoiding over-utilizing maximum analyst hours
$250x_1 + 450x_2 + 560x_3 + 450y_1 + 600y_2 + 900y_3 + 550z_1 + 700z_2 + 950z_3 - d_4^+ + d_4^- = 7700$	Avoiding over-utilizing maximum training hours
$x_1 + d_5^- = 1$	Selecting In-sourcing mode for task *X* of the project
$x_2 + d_6^- = 1$	Selecting Co-sourcing mode for task *X* of the project
$x_3 + d_7^- = 1$	Selecting Out-sourcing mode for task *X* of the project
$x_1 + x_2 + x_3 = 1$	Selecting one of the sourcing mode for the task *X* of the project
$y_1 + d_8^- = 1$	Selecting In-sourcing mode for task *Y* of the project
$y_2 + d_9^- = 1$	Selecting Co-sourcing mode for task *Y* of the project
$y_3 + d_{10}^- = 1$	Selecting Out-sourcing mode for task *Y* of the project
$y_1 + y_2 + y_3 = 1$	Selecting one of the sourcing mode for the task *Y* of the project
$z_1 + d_{11}^- = 1$	Selecting In-sourcing mode for task *Z* of the project
$z_2 + d_{12}^- = 1$	Selecting Co-sourcing mode for task *Z* of the project
$z_3 + d_{13}^- = 1$	Selecting Out-sourcing mode for task *Z* of the project
$z_1 + z_2 + z_3 = 1$	Selecting one of the sourcing mode for the task *Z* of the project
$500x_1 + 310x_2 + 1125x_3 + 600y_1 + 410y_2 + 925y_3 + 600z_1 + 410z_2 + 1325z_3 - d_{14}^+ + d_{14}^- = 3375$	Avoiding over- or under-utilizing expected budget
$900x_1 + 1100x_2 + 1500x_3 + 650y_1 + 800y_2 + 1200y_3 + 1000z_1 + 1200_2 + 1555_3 - d_{15}^+ + d_{15}^- = 3200$	Avoiding over- or under-utilizing labor hours
$x_j = 0$ or 1 for $j = 1, 2, 3$	
$y_j = 0$ or 1 for $j = 1, 2, 3$	
$z_j = 0$ or 1 for $j = 1, 2, 3$	

by combining with the ANP, DEMATEL and ZOGP methods in IT sourcing decision making problems.

In the meantime, the DEMATEL method was applied to compute the effects between criteria, divide a set of complex factors into dispatcher group and receiver group, and transform into a visible structural model. The ANP approach was employed to construct a decision model for making a strategic decision, transform qualitative judgments into quantitative values on the basis of the above well-formalized relations, and obtain a set of the preferences or explicit weights of each potential sourcing mode for each task of the project. Just looking at the preferences or priorities of the projects on the stage of ANP, however, is not enough to select the best alternatives in a limited resource environment. The ZOGP model was therefore used to assist the organization in finding an optimal solution without exceeding the limitation of its budget and other related resource. Finally, this integrated MCDM support model succeed in fully utilizing the available resources of the organization to find an optimal task sourcing portfolio to execute each task of the project.

Indeed, IT sourcing decision making and project task arrangement are necessary for all companies and industries. The motivations for companies to achieve effective management may differ and, besides cost, may involve considerations related to operations objectives, such as quality, flexibility and technology acquisition. Companies therefore need a systematic framework to assist IT decision makers in evaluating both quantitative and qualitative criteria in the evaluation process. Through this well-constructed hybrid Multi-Criteria Decision Model, the results of our research have shown that a proper operations strategy and management of both resource usage and task arrangement in accordance with priorities laid out in sourcing mix decision can be central to keeping the company working on an even keel and able to respond quickly and effectively to changes in internal or external circumstances.

6. Conclusions

It is widely accepted that a business requires constantly evolving strategies that can not only adapt to external environmental change but also identify internal value-added activities and, even more effectively, achieve the goals of management. Espino-Rodriquez and Padron-Robaina (2004), moreover, argue that a successful operations strategy is a series of structured and established tactical maneuvers of the task assignment. An organization is, therefore, required to take advantage of internal resource and exactly in charge of the main core competencies and capabilities but also need to embrace co-sourced and outsourced IT solutions to extend the breadth of resources available to it and its operational flexibility, as well as to maximize its in-house potential since an organization that is expert in many things might nevertheless have weaknesses in its provision of products or services.

The decision as to whether to keep IT/IS functions in-house or contract with a third-party service provider is entirely strategic and can dramatically impact the bottom line of any organization. As with most organizational decisions, no single particular sourcing mode is inherently superior to the others and the choice is contingent upon organizational goals and contextual and project-specific factors. In order to adequately evaluate the sourcing decision, an organization requires sophisticated tools and techniques to ensure corrective action can be taken proactively and that tasks can be assigned appropriately.

In this study, we concluded a hybrid Multi-Criteria Decision Making for reaching effective problem-solving. This hybrid MCDM model, combining the DEMATEL method, the ANP method and the ZOGP method, can not only cope with the interdependencies between the criteria for IS sourcing arrangement but also achieve the organizational goals of optimizing operations strategy and management by fully utilizing limited resources and clearly determining optimal task arrangement.

A feasible evaluation process of sourcing decision in this integrated model of this article could be extended and applied to any range of potential tasks, projects or systems, be they current or future. This model, therefore, could be a dynamic decision model that needs access to both internal and external resources simultaneously, and such a well-constructed evaluation process will conform more close to the decision need in reality.

Finally, it is expected that this work will offer a quantitative decision model using the DEMATEL, ANP and ZOGP methods, and determine the weights of criteria for final ranking of the alternative that can help practitioners to evaluate how well each sourcing decision is aligned with the company's strategic direction, set priorities, and reap the greatest possible benefits from their sourcing decision.

Appendix A. Brief of the DEMATEL method

Decision making trial and evaluation laboratory (DEMATEL) is a comprehensive method for building and analyzing a structural model with involving causal relationships between complex factors (Warfield, 1976). DEMATEL was developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976. The method can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system (Tzeng et al., 2007). Thus, it is practical and useful for visualizing the structure of complicated causal relationships with matrices or diagrams. The steps of the DEMATEL method are described as following:

Step 1: Producing the direct-relation matrix

Suppose that a system contains a set of criteria $C = \{C_1, C_2 \dots C_n\}$, and the pairwise comparisons are determined to model with respect to a mathematical relation. From any group of direct matrices of respondents it is possible to derive an average matrix A, which is an initial direct-influence matrix, in where t_{ij} is denoted as the influential degree of which the criterion C_i to the criterion C_j. Accordingly, all main diagonal elements t_{ij} of matrix A are set to be zero.

$$A = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} 0 & t_{12} & \dots & t_{1n} \\ t_{21} & 0 & \dots & t_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ t_{n1} & t_{n2} & \dots & 0 \end{bmatrix} \end{array}$$

Step 2: Normalizing the direct-relation matrix

On the basis of the direct-relation matrix A, the normalized direct-relation matrix M can be obtained through formulas (A.1) and (A.2), in which all evaluation principles diagonal elements are equal to zero (Chiu et al., 2006).

$$\boldsymbol{M} = k \cdot \boldsymbol{A} \tag{A.1}$$

$$k = \mathrm{Min}\left(\frac{1}{\max_{1 \leqslant i \leqslant n} \sum_{j=1}^{n} |a_{ij}|}, \frac{1}{\max_{1 \leqslant j \leqslant n} \sum_{i=1}^{n} |a_{ij}|}\right), \quad i,j \in \{1,2,3,\dots,n\} \tag{A.2}$$

Step 3: Obtaining the total-relation matrix

Once the normalized direct-relation matrix M has been obtained, the total-relation matrix S can be derived by using formula (A.3), where the I is denoted as the identity matrix (Chiu et al., 2006).

$$\boldsymbol{S} = \boldsymbol{M} + \boldsymbol{M}^2 + \boldsymbol{M}^3 + \cdots = \sum_{i=1}^{\infty} \boldsymbol{M}^i = \boldsymbol{M}(\boldsymbol{I} - \boldsymbol{M})^{-1} \qquad (A.3)$$

Step 4: Compute dispatcher group and receiver group
Using the values of $D-R$ and $D+R$ where R is the sum of columns and also D is the sum of rows in matrix S, a level of influence to others and a level of relationship with others are defined, as shown in formulas (A.4)–(A.6) (Wu & Lee, 2007a). Some criteria having positive values of $D-R$ have higher influence on one another and are assumed to have higher priority and are called dispatcher; others having negative values of $D-R$ receiving more influence from another are assumed to have a lower priority and are called receiver. On the other hand, the value of $D+R$ indicated degree of relation between each criterion with others and criteria having more values of $D+R$ have more relationship with another and those having little values of $D+R$ have less of a relationship with others (Seyed-Hosseini, Safaei, & Asgharpour, 2006).

$$\boldsymbol{S} = [s_{i,j}]_{n\times n}, \quad i,j \in \{1,2,3,\ldots,n\} \qquad (A.4)$$

$$\boldsymbol{D} = \sum_{j=1}^{n} s_{i,j} \qquad (A.5)$$

$$\boldsymbol{R} = \sum_{i=1}^{n} s_{i,j} \qquad (A.6)$$

Step 5: Set threshold value and obtain the impact-digraph-map
To obtain an appropriate impact-digraph-map, decision-maker must set a threshold value for the influence level. Only some elements, whose influence level in matrix S are higher than the threshold value, can be chosen and converted into the impact-digraph-map. The threshold value is decided by the decision-maker or by experts through discussion (Tzeng et al., 2007). An impact-digraph-map can be acquired by mapping the dataset of ($D+R$, $D-R$), where the horizontal axis $D+R$, and the vertical axis $D-R$ (Wu & Lee, 2007a).

Appendix B. Brief of ANP

ANP (Analytic Network Process) is an extension of the famous AHP (Analytic Hierarchy Process). The AHP is designed for multi-objective, multi-criterion, and multi-actor decisions with and without certainty, for any number of alternatives. However, the elements within the hierarchy of various rules are often interdependent in reality. Saaty (2001) develops the ANP for decision-rakings priorities without making assumptions about a unidirectional hierarchical relationship among decision levels. The major difference between ANP and AHP is that ANP can handle interdependences of higher-level elements from lower-level elements, and the independence of the elements within a level, by obtaining the composite weights through the development of a supermatrix. Therefore, ANP methodology can improve and support a complex, networked decision-making with various intangible criteria (Hallikainen, Kimpimaki, & Kivijarvi, 2006).

ANP approach mainly consists of two stages, construction of the network and calculation of the priorities of the elements. All of the interactions between the elements should be considered when building the structure of the problem (Karsak et al., 2002). These interactions are evaluated using pairwise comparisons. Along with asking about that how much importance of a criterion has compared with another criterion with respect to the interests or preferences of respondents. The candidate alternatives are also evaluated by pairwise comparisons with respect to what is the higher degree of satisfaction for each criterion. Both kinds of related values can be determined by using a scale of 1–9 to represent equal importance to extreme importance (Saaty, 2001). This yields an $n \times n$ matrix G as follows:

$$G = [g_{ij}] = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \ldots & C_n \end{array} \\ \begin{bmatrix} 1 & g_{12} & \ldots & g_{1n} \\ 1/g_{12} & 1 & \ldots & g_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/g_{1n} & 1/g_{2n} & \ldots & 1 \end{bmatrix} \end{array},$$

where $g_{ij} = 1$ and $g_{ji} = 1/g_{ij}, i,j = 1,2,\ldots,n$. In matrix G, the problem becomes one of assigning to the n criteria $C_1, C_2, \ldots, C_n$ a set of numerical weights $w_1, w_2, \ldots, w_n$ that reflect the recorded judgments. If G is a consistency matrix, the relations between weights w_i and judgments g_{ij} are simply given by $w_i/w_j = g_{ij}$ (for i, j = 1, 2,...,n).

$$G = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \ldots & C_n \end{array} \\ \begin{bmatrix} w_1/w_1 & w_1/w_2 & \ldots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \ldots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \ldots & w_n/w_n \end{bmatrix} \end{array}.$$

Saaty (2001) suggested that the largest eigenvalue λ_{max} would be

$$\lambda_{\max} = \sum_{j=1}^{n} g_{ij} w_j / w_i$$

If G is a consistency matrix, eigenvector X can be calculated by

$$(G - \lambda_{\max} I)X = 0$$

Saaty (2001) proposed to utilize the consistency index (CI) and consistency ratio (CR) to verify the consistency of the comparison matrix. CI and CR are defined as follows:

$$CI = (\lambda_{\max} - n)/(n-1), \quad CR = \frac{CI}{RI}$$

where RI indicates the average consistency index over numerous random entries of the reciprocal matrices with same orders. If $CR \leq 0.1$, the estimate is accepted; otherwise, a new comparison matrix is solicited until $CR \leq 0.1$. Finally, the result of these computations forms a supermatrix. After the computation of the relationship of the supermatrix and the comprehensive evaluations, it is possible to derive the interdependence of each valuation criteria and options and the weighting of priorities. The higher the priority weightings, the more priority will be placed. In this manner, it is possible to select the most appropriate option. Here, Super Decisions 1.6.0 software can be deployed to calculate the eigenvalue, eigenvector and obtain the weighting of priorities of the alternatives.

Appendix C. Brief of zero-one goal programming (ZOGP)

Goal programming (GP) is a well-known multiple-objective programming technique. It was first introduced by Charnes et al. (1995). The purpose of GP is to minimize the deviations between the achievement of goals and their aspiration level. Therefore, the zero-one goal programming (ZOGP) is good to be used to handle the Multi-Criteria Decision Making (MCDM) problem and attain the objectives of an organization while considering restricted resources. The ZOGP model is described as follows (Wey & Wu, 2007):

$$
\begin{aligned}
&\text{Minimize } \; Z = P_K(w_j d_i^+, w_j d_i^-)\\
&\text{Subject to } \sum_{j=1}^{n} a_{ij} x_j + d_i^- - d_i^+ = b_i \quad \text{for } i = 1,2,\ldots,m,\; j = 1,2,\ldots,n\\
&\qquad x_j + d_l^- = 1 \quad \text{for } i = m+1,\ldots,m+n;\; j = 1,2,\ldots,n\\
&\qquad d_i^+ \geq 0,\;\; d_i^- \geq 0 \;\; \text{for } \forall_i\\
&\qquad x_j = 0 \text{ or } 1 \quad \text{for } \forall_j
\end{aligned}
$$

where Z denotes the sum of the deviation variables from K goals considered; i indicates m restricted resources; j indicates n selected alternatives; P_K indicates a preemptive priority $(P_1 > P_2 > P_3 >>> P_K)$ for goal K; x_j indicates the binary variable of the jth alternative. When $x_j = 1$, then the jth alternative is selected; when $x_j = 0$, then the jth alternative is not selected. and are the positive and negative deviation variables for the ith restricted resource; w_j represents the ANP mathematical weight on the jth alternative; a_{ij} is the usage of the jth alternative on the ith restricted resource; b_i denotes the ith available resource or limitation factors that must be considered in the process of decision making. Here, LINGO 8.0 can be used to aid calculation and obtain the final optimal solution.

References

Adam, E. E., & Swamidass, P. (1989). Assessing operations management from a strategic perspective. *Journal of Management, 15*(2), 181–203.

Aragones-Beltran, P., Aznar, J., Ferrıs-Onate, J., & Garcıa-Melon, M. (2008). Valuation of urban industrial land: An analytic network process approach. *European Journal of Operational Research, 185*(1), 322–339.

Barthelemy, J., & Geyer, D. (2005). An empirical investigation of IT outsourcing versus quasi-outsourcing in France and Germany. *Information and Management, 42*(4), 533–542.

Bettis, R. A., Bradley, S., & Hamel, G. (1992). Outsourcing and industrial decline. *Academy of Management Executive, 6*(1), 7–22.

Blumberg, D. F. (1998). Strategic assessment of outsourcing and downsizing in the service market. *Managing service Quality, 8*(1), 5–18.

Borman, M. (2006). Identifying the factors motivating and shaping cosourcing in the financial services sector. *Journal of Information Technology Management, 17*(1), 11–25.

Çekyay, B., Gümüssoy, C. A., & Ertay, T. (2005). IS project selection based on fuzzy-ANP and ZOGP. In *Proceedings of the 35th international conference on computers and industrial engineering* (pp. 19–22). Istanbul, Turkey.

Charnes, A., Cooper, W. W., & Ferguson, R. O. (1995). Optimal estimation of executive compensation by linear programming. *Management Science, 1*(2), 138–151.

Chen, R. S., & Shyu, J. Z. (2006). Selecting a weapon system using zero-one goal programming and analytic network process. *Journal of Information and Optimization Sciences, 27*(2), 379–399.

Chi, T. (1994). Trading in strategic resources: Necessary conditions, transaction cost problems, and choice of exchange structure. *Strategic Management Journal, 15*(4), 271–290.

Chiu, Y. J., Chen, H. C., Tzeng, G. H., & Shyu, J. Z. (2006). Marketing strategy based on customer behaviour for the LCD-TV. *International Journal and Decision Making, 7*(2/3), 143–165.

Clark, T., Zmud, R., & McCray, G. (1995). The outsourcing of information services: Transforming the nature of business in the information industry. *Journal of Information Technology, 10*(4), 221–237.

Coe, N. M. (2000). The externalization of producer services debate: The UK computer services sector. *The Services Industries Journal, 20*(2), 64–81.

Curtis, B., Kellner, M. I., & Over, J. (1992). Process modeling. *Communications of the ACM, 35*(9), 75–90.

Davis, M., Aquilano, N., & Chase, R. (1999). *Fundamentals of operations management*. New York: McGraw-Hill.

Dominguez Machuca, J. A., Alvarez, M. J., Domınguez, M. A., Garcıa, S., & Ruız, A. (1995). *Direccion de operaciones, Aspectos estrategicos en la produccion y los servicios*. Madrid: McGraw-Hill.

Espino-Rodriquez, T. F., & Padron-Robaina, V. (2004). Outsourcing and its impact on operational objectives and performance: A study of hotels in the Canary Islands. *International Journal of Hospitality Management, 23*(3), 287–306.

Ferdows, K., & De Meyer, A. (1990). Lasting improvements in manufacturing performance: In search of the theory. *Journal of Operations Management, 9*(2), 168–182.

Ferratt, T. W., Agarwal, R., Brown, C. V., & Moore, J. E. (2005). IT human resource management configurations and IT turnover: Theoretical synthesis and empirical analysis. *Information Systems Research, 16*(3), 237–255.

Garvin, D. A. (1998). *Managing quality*. New York: The Free Press.

Gilley, K. M., & Rasheed, A. (2000). Making more by doing less: Analysis of outsourcing and its effects on firm performance. *Journal of Management, 26*(4), 763–790.

Goo, J. H., Kishore, R., & Rao, H. R. (2000). A content-analytic longitudinal study of the drivers for information technology and systems outsourcing. In *Proceeding of the 21st international conference on information systems* (pp. 601–611). Brisbane, Australia.

Greaver, M. F. II., (1999). *Strategic outsourcing: A structured approach to outsourcing decisions and initiatives*. New York: Amacon.

Grover, V., Cheon, M. J., & Teng, J. T. C. (1996). The effect of service quality and partnership on the outsourcing of information systems functions. *Journal of Management Information Systems, 12*(4), 89–116.

Gupta, U. G., & Gupta, A. (1992). Outsourcing the IS function. *Information Systems Management, 9*(3), 44–50.

Gupta, M., & Zhender, D. (1994). Outsourcing and its impact on operations strategy. *Production and Inventory Management Journal, 35*(3), 70–76.

Hallikainen, P., Kimpimaki, H., & Kivijarvi, H. (2006). Supporting the module sequencing decision in the ERP implementation process. In *Proceedings of the 39th Hawaii international conference on system sciences* (pp. 1–10). Kauai, HI, USA.

Han, H. S., Lee, J. N., & Seo, Y. W. (2008). Analyzing the impact of a firm's capability on outsourcing success: A process perspective. *Information and Management, 45*(1), 31–42.

Hayes, R. H., & Wheelwright, S. C. (1984). *Restoring our competing edge: Competing through manufacturing*. New York: Wiley.

Janssen, M., & Joha, A. (2006). Motives for establishing shared service centers in public administrations. *International Journal of Information Management, 26*(2), 102–115.

Jennigs, D. (1997). Strategic guidelines for outsourcing decisions. *Strategic Change, 6*(2), 85–96.

Jharkharia, S., & Shankar, R. (2007). Selection of logistics service provider: An analytic network process (ANP) approach. *The International Journal of Management Sciences, 35*(3), 274–289.

Johnson, M. (1997). *Outsourcing in brief*. London: Biddles Ltd..

Johnston, R., Chambers, S., Harland, C., Harrison, A., & Slack, N. (1993). *Cases in operations management*. London: Pitman.

Karsak, E. E., Sozer, S., & Alptekin, S. E. (2002). Product planning in quality function deployment using a combined analytic network process and goal programming approach. *Computers and Industrial Engineering, 44*(1), 171–190.

Kishore, R., Agrawal, M., & Rao, H. R. (2004). Determinants of sourcing during technology growth and maturity: An empirical study of e-commerce sourcing. *Journal of Management Information Systems, 21*(3), 47–82.

Kotabe, M. (1989). Hollowing-out of US multinationals and their global competitiveness: An intrafirm perspective. *Journal of Business Research, 19*(1), 1–15.

Kotabe, M., & Murray, J. (1990). Linking product and process innovations and models of international sourcing in global competition: A case of foreign multinational firms. *Journal of International Business Studies, 21*(3), 383–408.

Krajewski, L., & Rizman, L. (2000). *Operations management; strategy and analysis*. MA, New York: Addison Wesley, Longman Inc., Reading.

Lacity, M. C., & Hirschheim, R. (1993). *The information systems outsourcing: Myths, metaphors, and realities*. New York: John Wiley and Sons.

Lee, J. W., & Kim, S. H. (2000). Using analytic network process and goal programming for interdependent information system project selection. *Computers and Operations Research, 27*(4), 367–382.

Lee, J. W., & Kim, S. H. (2001). An integrated approach for interdependent information system project selection. *International Journal of Project Management, 19*(2), 111–118.

Leong, G., Snyder, D., & Ward, P. (1990). Research in the process and content of manufacturing strategy. *Omega, 18*(2), 109–122.

Leung, L. C., Lam, K. C., & Cao, D. (2006). Implementing the balanced scorecard using the analytic hierarchy process and the analytic network process. *Journal of the Operational Research Society, 57*(6), 682–691.

Lin, Y. H., Chiu, C. C., & Tsai, C. H. (2008). The study of applying ANP model to assess dispatching rules for wafer fabrication. *Expert Systems with Applications, 34*(3), 2148–2163.

Liou, J. J. H., Tzeng, G. H., & Chang, H. C. (2009). Airline safety measurement using a novel hybrid model. *Journal of Air Transport Management, 13*(4), 243–249.

Liu, H. T., & Wang, W. K. (2009). An integrated fuzzy approach for provider evaluation and selection in third-party logistics. *Expert Systems with Applications, 36*(3), 4387–4398.

MacDonald, H. (1991). *Business strategy development, alignment and redesign*. Oxford and New York: Oxford University Press.

Mathirajan, M., & Ramanathan, R. (2007). A (0–1) Goal Programming Model for scheduling the tour of a marketing executive. *European Journal of Operational Research, 179*(2), 554–566.

McBride, N. (2009). Exploring service issues within the IT organization: Four mini-case studies. *International Journal of Information Management*. doi:10.1016/j.ijinfomgt.2008.11.010.

McFarlan, F. W., & Nolan, R. L. (1995). How to manage an IT outsourcing alliance. *Sloan Management Review, 36*(2), 9–23.

Meade, L. M., & Sarkis, J. (1999). Analyzing organizational project alternatives for agile manufacturing processes: An analytical network approach. *International Journal of Production Research, 37*(2), 241–261.

Meade, L. M., & Presley, A. (2002). R&D project selection using the analytic network process. *IEEE Transactions on Engineering Management, 49*(1), 59–66.

Neirotti, P., & Paolucci, E. (2007). Assessing the strategic value of Information Technology: An analysis on the insurance sector. *Information and Management, 44*(6), 568–582.

Ozanne, M. R. (1997). Outsourcing: Managing strategic partnerships for the virtual enterprise. *Fortune*, S1–S48.

Peak, D., Guynes, C. S., & Kroon, V. (2005). Information technology Alignment Planning – A case study. *Information and Management, 42*(4), 619–633.

Perry, W., & Devinney, S. (1997). Achieving quality outsourcing. *Information Systems Management, 14*(2), 23–26.

Powell, P. H. (1993). Causality in the alignment of information technology and business strategy. *Journal of Strategic Information Systems, 2*(4), 320–334.

Quinn, J. B., Doorley, T. L., & Paquette, P. C. (1990). Technology in services: Rethinking strategic focus. *Sloan Management Review, 31*(2), 79–87.

Quinn, J. B., & Hilmer, F. G. (1994). Strategic Outsourcing. *Sloan Management Review, 35*, 43–55.

Saaty, T. L. (2001). *The analytic network process*. Pittsburgh: RWS Publications.

Schniederjans, M. J., & Wilson, R. L. (1991). Using the analytic hierarchy process and goal programming form information system project selection. *Information and Management, 20*(5), 333–342.

Schwartz, J. (1992). Ordering out of IS. *CIO*, 18.

Seyed-Hosseini, S. M., Safaei, N., & Asgharpour, M. J. (2006). Reprioritization of failures in a system failure mode and effects analysis by decision making trial and evaluation laboratory technique. *Reliability Engineering and System Safety, 91*(8), 872–881.

Skinner, W. (1969). Manufacturing-missing link in corporate strategy. *Harvard Business Review, 47*, 136–145.

Srivanaboon, S., & Milosevic, D. Z. (2006). A two-way influence between business strategy and project management. *International Journal of Project Management, 24*(6), 493–505.

Tan, J. C., & Harket, P. T. (1999). Designing workflow coordination: Centralized versus market-based mechanisms. *Information Systems Research, 10*(4), 328–342.

Tsai, W. H., & Chou, W. C. (2009). Selecting management systems for sustainable development in SMEs: A novel hybrid model based on DEMATEL, ANP, and ZOGP. *Expert Systems with Applications, 36*(2), 1444–1458.

Tsai, W. H., Chou, W. C., & Hsu, W. (2009). The sustainability balanced scorecard as a framework for selecting socially responsible investment: An effective MCDM model. *Journal of the Operational Research Society, 60*(10), 1396–1410.

Tsai, W. H., & Hsu, J. L. (2008). Corporate social responsibility programs choice and costs assessment in the airline industry – A hybrid model. *Journal of Air Transport Management, 14*(4), 188–196.

Tzeng, G. H., Chiang, C. H., & Li, C. W. (2007). Evaluating intertwined effects in e-learning programs: a novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert Systems with Applications, 32*(4), 1028–1044.

Venkatesan, R. (1992). Strategic sourcing – To make or not to make. *Harvard Business Review, 70*, 98–107.

Warfield, J. (1976). *Societal systems: Planning, policy, and complexity*. New York: Wiley Interscience.

Weber, R., Werners, B., & Zimmerman, H. J. (1990). Planning models for research and development. *European Journal of Operational Research, 48*(2), 175–188.

Werbach, K. (2000). Syndication: The emerging model for business in the Internet era. *Harvard Business Review, 78*(3), 84–93.

Wey, W. M., & Wu, K. T. (2007). Using ANP priorities with Goal Programming in resource allocation in transportation. *Mathematical and Computer Modelling, 46*(7–8), 985–1000.

William, R. K., & Yogesh, M. (1999). Developing a framework for analyzing IS sourcing. *Information and Management, 37*(6), 323–334.

Williamson, O. (1979). Transaction cost economics: The governance of contractual relations. *Journal of Law and Economics, 22*(2), 233–261.

Wu, W. W., & Lee, Y. T. (2007a). Developing global managers' competencies using the fuzzy DEMATEL method. *Expert Systems with Applications, 32*(2), 499–507.

Wu, W. W., & Lee, Y. T. (2007b). Selecting knowledge management strategies by using the analytic network process. *Expert Systems with Applications, 32*(3), 841–847.

Yang, C., & Huang, J. B. (2000). A decision model for IS outsourcing. *International Journal of Information Management, 20*(3), 225–239.