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Knowledge sharing assessment: An Ant Colony System based Data Envelopment Analysis approach

Chuen Tse Kuah [a], Kuan Yew Wong [a,*], Manoj Kumar Tiwari [b]

[a] Department of Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 UTM Skudai, Malaysia
[b] Department of Industrial Engineering and Management, Indian Institute of Technology, 721302 Kharagpur, India

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ABSTRACT

Knowledge sharing as one of the most crucial processes in knowledge management, operates in a dynamic environment. Dedicated tools to measure its performance under such an environment are not found in the literature. This paper aims to fill this void by proposing a hybrid model based on Data Envelopment Analysis (DEA). Monte Carlo simulation is incorporated into the model to handle stochastic data. In addition, to improve the model's accuracy, the Ant Colony System (ACS) metaheuristic is blended with Monte Carlo simulation and DEA. The model is named ACS-DEA and is found to be able to increase the accuracy and reliability of the results. Although this model aims to assess knowledge sharing performance, it could also be used in other relevant fields in dynamic settings.

1. Introduction

In this rapidly changing world, knowledge has become the most powerful leverage for an organization to achieve competitive advantages. It is therefore crucial for an organization to effectively manage its knowledge. Knowledge Management (KM) can be broken down into a few sub-processes such as knowledge creation, knowledge storing, knowledge sharing, and knowledge utilization. Indeed, all these processes play important roles in forming a successful KM program. Particularly, knowledge sharing is well-recognized as the main element for KM to thrive. For many organizations, getting workers to share and contribute knowledge is the emphasis of their KM initiatives. However, as revealed by past research, most existing frameworks and assessment tools broadly cover the area of KM, and only few are targeted specifically at knowledge sharing (Liebowitz & Chen, 2003; Small & Sage, 2006). Effectively managing and evaluating knowledge sharing performance have emerged to become a critical research subject (Liu & Tsai, 2008). Through performance assessment, organizations could measure how well they are performing in knowledge sharing and then determine the appropriate improvement strategies and resource allocations for their projects.

Recognizing the needs, this paper proposes the use of Data Envelopment Analysis (DEA), integrated with Ant Colony System (ACS) and Monte Carlo simulation, to devise a knowledge sharing assessment model. DEA, proposed by Charnes, Cooper, and Rhodes (1978) is a methodology to measure the efficiencies of a group of homogenous organizations without involving much subjective judgments. Since knowledge sharing is stochastic in nature, Monte Carlo simulation is utilized to introduce stochasticity into the DEA model. ACS is used to further enhance the accuracy of the model.

Following this introduction, a review on knowledge sharing and existing evaluation models will be presented. Next, the developed knowledge sharing assessment model will be explained. Then, to demonstrate the applicability of the model, a real world application will be presented. Finally, the paper concludes by giving a summary of the work and some future research directions.

2. Literature review

2.1. Knowledge sharing

Knowledge sharing refers to the exchange and transfer of knowledge among individuals, groups, and organizations for the purpose of improving organizational competitiveness by the effective exchange, integration, and synergy of knowledge (Lee, 2001; Chen, 2008; Lawson, Petersen, Cousins, & Handfield, 2009). It can also be viewed as a combination of interaction, communication, and learning processes that allows people to acquire knowledge from others. It fosters a learning environment and permits the creation and recycling of specialized knowledge (Dyer & Nobeoka, 2000).

Knowledge sharing contributes towards organizational creativity. Paul, William, Abraham, and Xiao (2004) suggested that new product development is strongly correlated with knowledge sharing. In addition, Law and Ngai (2008) revealed that knowledge

* Corresponding author. Tel.: +60 7 5534691; fax: +60 7 5566159.
E-mail addresses: wongky@mail.fkm.utm.my, kuanyewwong@yahoo.com (K.Y. Wong).

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sharing and learning behaviors are positively associated with business process improvement, product and service offerings, and organizational performance.

A proper Information Technology (IT) system and/or Knowledge Management System (KMS) facilitates knowledge sharing effectively by removing some of the barriers, for instances, lack of accessibility to organizational knowledge and geographical distance between members (Kim, Hong, & Suh, 2012). Having such systems in place also enables the formation of virtual Communities of Practice (CoPs). However, investing in these systems is costly and their benefits are very hard to measure. In fact, it is not an easy task to evaluate knowledge sharing performance due to its intangible and stochastic properties. This in turn would hinder the decision makers to allocate funds to support knowledge sharing initiatives and programs. Therefore, it is a necessity to have a model to assess the process in order to persuade them to support the initiatives continuously.

2.2. Knowledge sharing performance assessment

In order to properly manage the knowledge sharing process, its performance has to be evaluated. However, it is found that most models are broadly for KM, but those focusing on evaluating knowledge sharing are very limited. In this section, a few existing knowledge sharing performance evaluation models will be discussed, followed by some research issues in the field.

Among the first studies that recognized the need for assessing knowledge sharing, Liebowitz and Chen (2003) developed a knowledge sharing effectiveness model that consists of 25 questions covering four areas, namely, communication flow, KM environment, organizational facilitation, and the likelihood of knowledge sharing and KM being successful within the organization. The results could help an organization to pinpoint potential areas of improvement.

Quigley, Tesluk, Locke, and Bartol (2007) used incentive, goal-setting-social cognitive, and social motivation theories to examine knowledge sharing within dyads and its influence on individual performance. Their results showed that the effect of group-oriented incentive systems on the knowledge provider is enhanced when more positive norms for knowledge sharing exist among dyad members. When the recipient trusts the provider, his/her self-efficacy has a stronger relationship with performance goals.

Chen, Chen, Lin, and Chen (2010) proposed a fuzzy-based method centered on trust evaluation between a knowledge requester and a knowledge supplier. They believed that the level of trust reflects the willingness of a knowledge supplier to share his/her knowledge. Their work has produced a decision making support knowledge sharing model.

More recently, Social Network Analysis (SNA) was used by Kim et al. (2012) to develop a diagnosis framework for identifying knowledge sharing activities in CoPs and to suggest strategies for individual CoPs. Their research is significant because it provides a SNA framework to analyze knowledge sharing.

The studies reviewed above focus on different elements of knowledge sharing, such as knowledge workers and CoPs. However, none of them provides a method to benchmark the knowledge sharing performance of an organization relative to its competitors. It is important to know how well an organization is performing in comparison with other market players because through benchmarking, an organization would understand how efficient it is really performing.

Moreover, it is found that most of the existing models are qualitative studies which have used interviews and observation to evaluate knowledge sharing. Generally, qualitative studies provide a good understanding on the organizational cultures that hinder or promote knowledge sharing. However, these studies are deemed to be lack of objectiveness and therefore, they cannot reflect how well an organization is performing as compared with other organizations. On the other hand, through quantitative research, numerical results and causal relationships can be obtained. Quantitative approaches can be used to measure knowledge sharing and the extent of its impact on both decision making and performance of organizations. In addition, it can eliminate the drawback of subjective judgment in qualitative methods.

With that being said, more research that uses objective measures of knowledge sharing is needed. Nevertheless, objectively evaluating knowledge sharing poses some challenges. First, measures to assess knowledge sharing are not well-established, therefore an appropriate set of measures has to be developed. These measures, serve as proxies, ideally are to comprehensively capture an organization's knowledge sharing performance. Values of the measures have to be collected and then combined to be used as an indicator.

The second challenge lies in the nature of the data related to knowledge sharing which would more likely to be stochastic instead of deterministic. If only a single value is collected for each measure, the results would be merely a snapshot of knowledge sharing performance at a specific moment. Given the dynamic setting of knowledge sharing in any organization, only a snapshot would render the results unreliable. Thus, a method that can handle non-deterministic data and produce statistical results is highly desirable in order to give managers a better performance overview.

This leads to the third challenge that is the accuracy of the results, which is affected directly by the data collected for the measures. Intuitively, collecting more data should improve the variance and accuracy of their distribution. However, since collecting data in a large quantity is both costly and time consuming, an organization would typically set a budget on the total number of data to be collected. Therefore, an important feature of a knowledge sharing performance measurement model would be the capability to allocate the data collection budget effectively so that the results' accuracy can be optimized.

In order to address these challenges, the study's aims are to:

1. Establish a set of proxy measures for knowledge sharing evaluation,
2. Develop a knowledge sharing assessment model by utilizing Data Envelopment Analysis (DEA),
3. Handle stochastic data using Monte Carlo simulation, and
4. Incorporate Ant Colony System (ACS) to optimize the results' accuracy.

3. Developing a knowledge sharing assessment model

As shown in Fig. 1, knowledge sharing is treated as a process that transforms multiple inputs into multiple outputs. These input and output measures have been selectively adopted from the KM literature and will be explained in the next section which is followed by the elucidation of the developed model in several progressions.

3.1. Knowledge sharing measures

The input measures are the enablers of knowledge sharing process. The first input, X_1, is the number of knowledge workers (Ahmed, Lim, & Zairi, 1999; Govender & Pottas, 2007; Holtshouse, 2010; Jafari, Rezaeenour, Akhavan, & Fesharaki, 2010; Nathan & Soni, 2008; Robinson, Carrillo, Anumba, & Al-Ghassani, 2005; Ross, Ross, Dragonetti, & Edvinsson, 1998; Von Krough, Roos, & Kleine, 1999; Wen, 2009). Knowledge resides in workers' minds. In order to be beneficial for an organization, they must be willing to externalize their know-how and share their knowledge, expertise, and