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Media Selection in Knowledge Transfer: A Decision Model

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ABSTRACT

Managing knowledge transfer is a complex issue: when firms attempt to accelerate knowledge transfer at a rational cost, there is often a byproduct of knowledge spillover which harms the firms' competitive advantages. As the channel of knowledge transfer, media play a vital role for the success of knowledge transfer. However, the extant literature offers neither comprehensive framework nor a decision method to guide firms' media selection in knowledge transfer. This article develops a framework of media selection from the perspectives of performance, cost, and risk of knowledge spillover, and proposes a decision model of media selection in knowledge transfer based on analytic hierarchy process (AHP). Finally, this article applies the model to a case study to verify its effectiveness in practice. The framework is helpful to guide firms' media selection, and the decision model is valuable to facilitate firms' media selection in big knowledge transfer projects.

KEYWORDS

Analytic Hierarchy Process (AHP), Knowledge Spillover, Knowledge Transfer, Media, Multiple Criteria Decision, Systemic Thinking

INTRODUCTION

Knowledge is one of the most important resources of firms to gain competitive advantages (Huong, Katsuhiro, & Chi, 2011). Firms transfer knowledge to accomplish the benefits and undertake the costs and potential risks (Argote & Ingram, 2000; Turner & Makhija, 2006). Moreover, globalization brings in more opportunities and challenges for knowledge transfer (Muhammad Wasim & Ali, 2017; Yadav, Adya, Sridhar, & Nath, 2009). Specifically, globalization makes firms can access worldwide knowledge by establishing subsidies or constructing collaborations with external organizations or individuals (Wang, Lu, Lee, & Yeh, 2017). However, separation across time and space brings in more difficulties for knowledge transfer (Aman & Nicholson, 2009). Nowadays, the rapid development of information and communication technologies increases firms' media options for knowledge transfer, which makes that knowledge transfer is becoming more and more extensive and important for firms (Chow, 2011; Guo & D'Ambra, 2009; Shin-Yuan, Tsan-Ching, David, Albert, & Kuanchin, 2012). Then, an important issue is to select proper media when firms face some specific knowledge transfer

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projects, including traditional media such as face-to-face, telephone, and document as well as new media such as email, instant message, and teleconference (Oke & Idiagbon-Oke, 2010).

Many theories have been developed to guide media selection in knowledge transfer, including media richness theory, channel expansion theory, and social influence theory (Carlson & Zmud, 1999; Daft & Lengel, 1986; Fulk, Schmitz, & Steinfield, 1990; Venkatesh & Zhang, 2010). However, these theories are not very effective in practice (Carlson & Zmud, 1999). For example, email, with a moderate richness rating, is often chosen by communicators for highly equivocal tasks (Kock & Davison, 2003; Markus, 1994), contradicting the prediction of media richness theory. Facts violating other theories also have been found (Rice, 1993; Rice & Aydin, 1991). Moreover, benefits that firms can obtain from knowledge largely depend on the knowledge's scarcity (Barney, 2001). It is found that confidentiality depends on media attributes (Sillince, 1997). However, restraint of knowledge spillover, another important aspect in knowledge transfer, is seldom considered in media selection before (Oke & Idiagbon-Oke, 2010; Palvia, Pinjani, Cannoy, & Jacks, 2011).

Through the above analysis, existing studies acknowledge the roles of media in knowledge transfer, but they just focus on one dimension of knowledge transfer objectives separately. The lack of a comprehensive framework produces controversies in theoretical studies and puzzles the media selection in knowledge transfer practices. Then, how do media influence knowledge transfer systematically? How do individuals and firms choose media effectively in knowledge transfer? As a result, a more effective media selection framework and model in knowledge transfer with systemic thinking should be developed to advance existing studies and guide media selection practices (Carlson & Zmud, 1999; Davenport & Prusak, 1998; Dennis, Fuller, & Valacich, 2008).

This paper attempts to suggest a new framework and a new model of media selection guided by systemic thinking. First, prior media selection studies mainly address this question from the view of the sender or the recipient (Watson-Manheim & Bélanger, 2007). However, knowledge transfer is an interactive process, and its success requires efforts from both sides. Thus, examining the whole knowledge transfer process, this paper analyzes how media influence knowledge transfer results comprehensively. Then, this paper constructs a framework of media selection in knowledge transfer from performance, cost, and risk of knowledge spillover perspectives. Second, Carlson and Dvais (1998) found that different factors play key roles under different conditions in media selection in knowledge transfer. For example, the extent to which perceived usefulness influences media usage varies significantly (Davis, 1989; Hsiao & Tang, 2015), and factors such as others' attitudes and person/technology interaction are more important for newer media choice than for traditional media choice (Treviño, Webster, & Stein, 2000). Thus, some media are not inherently better than others, and the appropriateness of media is determined by the task and the objectives of knowledge transfer (Davis, 1989; Dennis et al., 2008; Treviño et al., 2000). Therefore, facing a media selection issue, firms should first determine the selection criteria and their weights, and then assess alternative media based on these criteria. In other words, a decision model of media selection should be constructed. Accordingly, this paper develops a decision model of media selection in which the analytic hierarchy process (AHP) method is used as an example, and applies the decision model to a case which has been investigated by Davenport and Prusak (1998) from a new perspective to illustrate its effectiveness. Third, this study contributes to the settlement of the controversies in existing studies. The comprehensive framework as well as the allowance of varying of the importance of influencing factors makes it have strong explanation capability to settle controversies of media selection in existing studies.

The rest of the paper is organized as follows. Following this section, this paper offers a review of media selection studies, which show the necessity to research media selection with systemic thinking and are relevant to the development of the framework of media selection. Next, this paper puts forward the framework to analyze the media selection in knowledge transfer. Then, this study suggests a model to guide media selection based on AHP in the method section, and confirms the effectiveness of the model using a case study in the analysis and results section. Discussion and conclusion are given at the end.

LITERATURE REVIEW

Knowledge transfer is the process by which individuals, teams or departments are influenced by others' experience (Argote & Ingram, 2000). The attributes of knowledge influence the knowledge transfer process significantly. Specifically, the tacitness, complexity, and specificity make it difficult to transfer knowledge successfully, and scholars usually label knowledge's resistance for transfer as stickiness (Szulanski, Ringov, & Jensen, 2016).

Media serve as the channels through which knowledge flows from the sender to the recipient, and influence the knowledge transfer significantly (Chidambaram, Lim, Chuan Chan, & Han, 2001). Initially, scholars focused on traditional media, which are face-to-face, telephone, and document (Daft, Lengel, & Treviño, 1987). As information technology develops, a lot of new media are available for knowledge transfer (Rice, 1992). For example, e-mail, instant messaging, and video conference are widely used in knowledge transfer (Dennis et al., 2008). Recently, digital platforms develop rapidly and allow a lot of people to share knowledge with many different types of media (Barrett, Davidson, Prabhu, & Vargo, 2015). How to choose media wisely has attracted scholars' interests for a long time. Three theories, i.e., media richness theory, social influence theory, and channel expansion theory, are influential in this field.

Media richness theory examines how media influence knowledge transfer performance. As equivocality, which means the existence of multiple and conflicting interpretations of the meaning of knowledge, impedes knowledge transfer and information communication (Daft & Lengel, 1986), media richness theory suggests that media differ in their abilities to conquer equivocality and facilitate understanding, which are determined by media attributes such as feedback, multiplicity of cues, language variety, and personal focus (Daft et al., 1987). Daft el al. (1987) ordered traditional media according to their richness, from highest to lowest, as follows: face-to-face, telephone, addressed documents, and finally, unaddressed documents. Media richness theory argues that the richer the media, the more capable the media are of transferring equivocal knowledge. Therefore, face-to-face media are preferred for knowledge containing equivocality, while written media are used for unequivocal knowledge.

However, media richness theory is not very effective in predicting individuals' media selection for new media, and people sometimes do not choose the most appropriate media suggested by media rich ness theory. For example, email, ranked as lean media, is also used for transfer of knowledge of high stickiness (N. Kock & Davison, 2003; Markus, 1994). Such inconsistencies have encouraged a reconsideration of the descriptive and predictive validity of media richness theory. Some alternative theories are developed to explain these contradictions as well as to predict individuals' media selection more effectively.

Channel expansion theory emphasizes experiential factors to better explain and predict user perceptions of the new media (Carlson & Zmud, 1999). It identifies media experience as an important factor for shaping how an individual develops richness perceptions for given media (Carlson & Zmud, 1999), which is measured in terms of the length of time the media have been used or the number of messages that have been sent. In fact, the media experience factor identified in channel expansion theory concerns the cost to the user when using some particular media. When individuals begin to use wholly new media, they have to spend a long time learning how to use them. This process costs individuals' energy and time. As communication participants acquire relevant experience about the media, they develop an associated knowledge base that may be used to encode and decode knowledge on the media more effectively. The more the media are used, the more experience the users accumulate, and the more comfortable they feel when using the media to transfer knowledge.

Similar as channel expansion theory, social influence theory also explains choices of media from a cost perspective, but it focuses on the cost of the collaborators in the knowledge transfer (Fulk et al., 1990). It proposes that variation with social forces, such as work group norms and co-worker/supervisor attitudes and behaviors, affects individuals' media selection (Fulk & Boyd, 1991; Karahanna

& Straub, 1999). If co-workers or supervisors are unfamiliar with the media selected, they have to spend a lot of time learning how to use the media, which costs them time and energy. If they dislike the media, they might be resistant to the knowledge transfer. As a result, a worker should consider the coworkers' and supervisors' attitudes towards the media he or she will select, and the firm should consider the sender and the recipient's attitudes towards the media that it will select (Arpaci, Yardimci Cetin, & Turetken, 2015). Otherwise, if some individuals are hostile towards the media selected, the cost and time of the knowledge transfer will increase. Thus, individual beliefs concerning the appropriate use of media as well as perceptions of media richness are, in part, socially constructed (Fulk et al., 1990). However, the effect of social influence on perceptions of media richness is still unclear, and divergent empirical results of relationships between social influence and media use and perceptions have been found, ranging from positive, negative, to nonsignificant relationships (Fulk, 1993; Rice, 1993; Rice & Aydin, 1991).

Recently, scholars suggest that firms should be cautious about knowledge spillover when selecting media to transfer knowledge according to the knowledge-based view (Oxley & Wada, 2009), because risk of knowledge spillover partly depends on media attributes (Sillince, 1997), and media of low and high richness induce different kinds of knowledge spillover risks. Tacitness is an effective self-protection mechanism to prevent knowledge spillover. Knowledge transfer using media of low richness might involve a knowledge codification process, which makes knowledge more explicit and accelerates knowledge spillover (Argote & Ingram, 2000). Therefore, firms should be cautious when using media of low richness and pay special attention to the risk of explicit knowledge spillover. On the other hand, Song et al. (2003) argued that human mobility is an effective mechanism for firms to acquire outside knowledge, especially ambiguous knowledge. Thus, "job hopping" by engineers and scientists is widely heralded as an important channel for knowledge spillover (Agarwal, Ganco, & Ziedonis, 2009). Therefore, firms should be cautious when using media of high richness and pay special attention to the risk of tacit knowledge spillover.

Above all, the relationship between media and knowledge transfer is complex, and many studies have shed light on this relationship. Media richness theory confirms that media attributes influence knowledge transfer performance, channel expansion theory and social influence theory suggest the cost consideration affects media selection in knowledge transfer, and recent studies argue that media selection in knowledge transfer should take privacy and knowledge spillover into consideration. However, although knowledge transfer has multiple objectives, existing studies mainly explore media selection with one objective, making the research results unilateral as guidance for media selection practice. Thus, constructing a comprehensive framework as well as a decision model for media selection in knowledge transfer is in urgent need for both theory and practice development.

PROPOSED FRAMEWORK

Cost-benefit Analysis and Media Selection in Knowledge Transfer

Cost benefit analysis is a systematic approach to estimate the strengths and weaknesses of alternatives and make comparison and choices (Boardman, Greenberg, Vining, & Weimer, 2017). In this process, the decision makers should estimate the potential benefits, costs, and risks of each alternative carefully, and then make decisions on the basis of calculations.

Knowledge transfer is important in firms and proper media should be selected to guarantee the performance of knowledge transfer. Meanwhile, knowledge transfer process will incur costs and risks, which should be considered in the media selection. According to the traditional decision theory, firms and media users will try to maximize their expected utilities determined by the benefits, the costs, and the risks when they select media in knowledge transfer (Clemen & Reilly, 2013). Thus, cost benefit analysis is a proper tool to investigate the media selection issue in knowledge transfer.

Integrating prior research and viewing knowledge transfer with multiple objectives, this paper develops a comprehensive framework of media selection in knowledge transfer from the perspectives of performance, cost, and risk of knowledge spillover, which is illustrated in Table 1.

Knowledge Transfer Performance

Knowledge transfer performance is defined here as the degree to which a firm believes that using some particular media would make the knowledge transfer successful (Davis, 1989), and it has three dimensions, mainly based on media richness theory, which are knowledge completeness, knowledge applicability and knowledge transfer speed.

First, knowledge completeness refers to the extent to which media can transfer knowledge from the sender to the recipient without omission and distortion. Knowledge transfer occurs frequently, but it is often incomplete (Argote & Ingram, 2000). Knowledge loss is one of the main reasons for knowledge transfer failure. Incomplete knowledge creates problems for those receiving it because its unfinished nature will cause confusion or questions relating to its role or application in the new context (Turner & Makhija, 2006). Concerning language variety, natural language can be used to convey understanding of a broader set of concepts and ideas, and knowledge can be transferred more fully using media with multiple cues when the knowledge is tacit (Daft et al., 1987). Furthermore, rapid feedback has a positive effect on the accuracy of the knowledge transferred (Turner & Makhija, 2006). Thus, it is important to select proper media, as media capacities for transferring knowledge in its completeness vary.

Second, knowledge applicability refers to the extent to which the knowledge transferred is contextualized for the recipient when some particular media are adopted. Because knowledge is often embedded in a specific context, it contains components specialized to particular tasks. Knowledge specificity is one reason that knowledge cannot be contextualized for a recipient, and the recipient should adapt the knowledge according to unanticipated variations in the work setting. Personal focus is the extent to which the sender can customize the knowledge to meet the needs of the recipient (Dennis & Kinney, 1998). Knowledge can be tailored to the situation of the recipient better when the personal focus of the media is high (Daft et al., 1987). Thus, different media have different capacities to conquer knowledge specificity and facilitate knowledge being applied into the recipient's context.

Finally, knowledge transfer speed refers to the time required for knowledge transfer to occur with respect to different media. To meet the challenge of a dynamic environment and gain first-mover advantage, firms should accelerate their knowledge transfer. Thus, the speed of knowledge transfer is an important consideration of firms' knowledge management. Different media have different capabilities of feedback and facilities for communication, which make their knowledge transfer speeds different from each other (Daft et al., 1987). Thus, media choice is important to the speed of knowledge transfer.

Table 1. Framework of media selection

First level	Second level
Knowledge transfer performance	Knowledge completeness
	Knowledge applicability
	Knowledge transfer speed
Knowledge transfer cost	Human resource cost
	Equipment cost
Risk of knowledge spillover	Risk of explicit knowledge spillover
	Risk of tacit knowledge spillover

Knowledge Transfer Cost

In researching knowledge transfer, what should be kept in mind is that knowledge transfer is not free (Kock, 2007). Teece (1997) estimated the cost of knowledge transfer to range from 2% to 59% of total cost of the 27 projects he analyzed, and the knowledge transfer cost varied significantly. Different types of media may consume dramatically different amounts of resources (Fulk & Boyd, 1991). Therefore, in addition to performance, cost is also an important consideration when firms select media (Rice, 1992). Knowledge transfer cost here refers to the degree to which a firm believes that using some particular media would be free of effort for the sender and the recipient and of other resources for the firm (Davis, 1989), which has two dimensions, namely human resource cost and equipment cost (Choi & Lee, 2003).

Firstly, human resource cost refers to the number, levels, and participation time of employees invested in the knowledge transfer when firms adopt some particular media (Porter, 1998). Individuals' efforts and time are firms' finite resources (Davis, 1989). For explicit knowledge, media of low richness are adequate and the average employees can quickly send the knowledge using a document or email, and the human resource cost of knowledge transfer is low. For tacit knowledge, however, rich media are required, and firms' experts should participate in the knowledge transfer. They have to invest a lot of time and energy into articulating the knowledge and helping the recipient adapt the knowledge according to the new context, and the human resource cost of knowledge transfer is high (Hansen, Nohria, & Tierney, 1999). Participants' attitudes also affect the human resource cost significantly. If they are resistant to the media selected, the knowledge transfer process takes a longer time, and they invest more time in the knowledge transfer, which increases the human resource cost.

Secondly, equipment cost refers to the value and the occupying time of the equipment invested in the knowledge transfer when firms use some particular media. Traditional media, such as face-to-face, telephone, and documents, usually do not require valuable equipment, and their equipment cost is low. For example, media such as documents just require paper. On the other hand, new media, including group decision support system and teleconference, need computer and network, and it is expensive for firms to construct and maintain their information systems (Kraut, Rice, Cool, & Fish, 1998). Thus, their equipment cost is high (Hansen et al., 1999).

Risk of Knowledge Spillover

Knowledge can bring in a sustainable competitive advantage only when the knowledge is valuable, scarce, inimitable, and hard to substitute (Barney, 1991). Knowledge spillover risks are different when using different media to transfer knowledge, and risk should be an important consideration when firms select media (Clemons & Hitt, 2004). Risk of knowledge spillover refers to the degree to which a firm believes that using some particular media to transfer knowledge would cause knowledge to spill out (Oke & Idiagbon-Oke, 2010). In particular, knowledge can be classified as explicit vs. tacit knowledge (Polanyi, 1967), and risk of knowledge spillover has two dimensions, namely risk of explicit knowledge spillover and risk of tacit knowledge spillover.

Firstly, risk of explicit knowledge spillover refers to the probability and the severity that firms' codified knowledge is appropriated by other firms. Media of low richness are effective in transferring explicit knowledge, but firms' knowledge is often complex, contextual and has tacit components. If firms select media of low richness to transfer knowledge, participants have to codify the tacit components into instructions or documents, which make knowledge more explicit. Tacitness is the self-protection mechanism for knowledge spillover (Das & Teng, 2000), and spillover of explicit knowledge is usually more serious than that of tacit knowledge. Thus, using media of low richness to transfer knowledge accelerates explicit knowledge spillover. In contrast, rich media mainly transfer knowledge through observation and learning by doing, and the tacit components of the knowledge are not transformed into explicit forms in this process. Thus, explicit knowledge spillover is relatively low when firms choose rich media to transfer knowledge.

Secondly, risk of tacit knowledge spillover refers to the probability and the severity that firms' tacit knowledge is appropriated by other firms. Firms' tacit knowledge is mainly stored in employees' brains, organizational practices, and procedures, and employee rotation is an important method of tacit knowledge transfer. If firms' tacit knowledge is mainly in employees' brains and is transferred using employee rotation (rich media), dismissal of employees having important secrets and know-how is an important risk of tacit knowledge spillover that firms face (Campione, 2003). If the knowledge that leaving employees hold is not mastered by others and there are no its explicit forms stored in the firm, the firm may lose the knowledge entirely, which drives the firm from an advantageous position to a disadvantageous position. Therefore, when firms use rich media to transfer tacit knowledge, they should assess the risk of employee loss as well as tacit knowledge spillover.

METHOD

When firms select media for knowledge transfer, they often should make a tradeoff among performance, cost, and risk of knowledge spillover (Haried & Claybaugh, 2017). Thus, an effective decision method is necessary to support their media selection. There are many methods aiming at solving decision problems with multiple criteria, and firms can choose one based on the particular media selection issue they face. Because AHP is an important method of solving decision problems with multiple criteria and simple (Saaty, 1980), this paper presents a decision model based on AHP as an example, and firms can similarly construct other decision models based on other evaluation methods.

AHP is a structured technique for organizing and analyzing complex decisions on the basis of mathematics and psychology (Saaty, 1980). There are three steps in AHP. The first step is to decompose the decision problem into a hierarchy of more easily comprehended criteria, and the objective of the second step is to determine the weights of the criteria and preferences of the alternatives through pairwise comparisons. Then, numerical priorities are calculated for each of the decision alternatives in the third step. AHP provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its criteria, for relating those criteria to overall goals, and for evaluating alternative solutions.

Hierarchy Construction

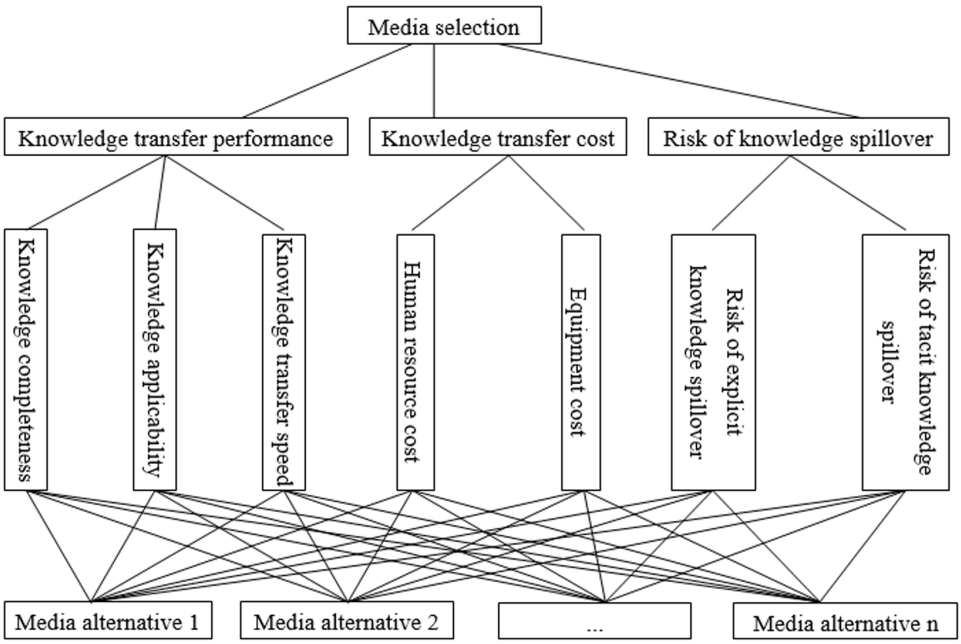
According to the framework of media selection, this paper constructs a hierarchy structure with four levels, which is illustrated in Figure 1. The highest level with only one element is the objective firms want to reach (selecting proper media), and the elements in the lowest level are the alternatives (media available). Elements in the middle levels are the criteria for evaluating those alternatives. In practice, firms can delete elements in the middle levels according to the task they face; for example, they can delete the criterion of risk of knowledge spillover and the elements below it if they believe that risk of knowledge spillover is not an important factor influencing their media selection.

Computation of the Weights of Elements below the Highest Level

Three steps are involved in this phase: pairwise comparisons, computing a vector of priorities, and measuring consistency (Yang & Huang, 2000).

The elements in a level below the objective of the hierarchy are compared in terms of their importance or preference to a given element that occupies the level immediately above the elements being compared. In this process, firms are required to give the magnitudes to the upper triangle of the square matrix using the relative scale measurement shown in Table 2, and the magnitudes of the down triangle are the reciprocals of the reverse position in the matrix, while the main diagonal of the matrix must consist of 1's. For example, a score of 1 represents indifference between the two elements, and 9 suggests the overwhelming dominance of the component under consideration (row component in the matrix) over the comparison component (column component in the matrix).

Figure 1. Hierarchy of media selection in knowledge transfer



Computing a vector of priorities and measuring consistency are mature and simple, and many software packages have been developed to accomplish these functions. Thus, this paper will not illustrate these issues here.

Weight Aggregation

Once all of the relative weights have been calculated, a composite weight for each media alternative is determined by aggregating the weights over the hierarchy for each alternative. This is also simple and can be accomplished with software. Then, firms can select the proper media by comparing values of media alternatives.

Table 2. Pairwise comparison scale for AHP preferences

Numerical ratings	Verbal judgments of preferences
9	Extremely preferred
7	Very strongly preferred
5	Strong preferred
3	Moderately preferred
1	Equally preferred
2, 4, 6, 8	Intermediate value between adjacent scale values
Reciprocals of above nonzero numbers	If *i* has one of the above nonzero numbers assigned to it when compared with *j*, then *j* has the reciprocal value when compared with *i*.

ANALYSIS AND RESULTS

Because knowledge transfer projects across countries are most complicated, we choose one such knowledge transfer project to verify the effectiveness of the proposed framework and decision model (Berry, 2014). Moreover, analyzing cases developed by other scholars from new perspectives can reduce the bias caused by extensive exposure to study of the cases (Yin, 2013), and this way can also lower the cost and difficulty of the case studies. Thus, a knowledge transfer project investigated by Davenport and Prusak (1998) is reexamined with the decision model of media selection put forward in this paper to illustrate its effectiveness.

When a key contractor for the Boston Harbor tunnel project transferred knowledge about an innovative improvement on a particular drilling process from a similar project in New Zealand, the media available for the contractor to select were sending memos and descriptions, creating diagrams and manuals, hiring consultants to give talks to the Boston crews, and worker rotation, and the contractor wanted to select media to transfer the knowledge effectively and efficiently (Davenport & Prusak, 1998).

Suppose that the vice president in charge of technology organized a team and convened a meeting to study the media selection issue. The team was constituted by the vice president, an expert familiar with the knowledge about drilling processes, a human resource manager, and a financial manager. Because they came from different departments, they stressed different aspects of knowledge transfer objectives. Specifically, the technological expert focused on knowledge transfer performance, the human resource manager wanted to guarantee the smoothness of the firms' activities, the financial manager stressed cost control, while the vice president mainly coordinated the decision process and made decisions. In this way, the team could think over all the key factors influencing media selection in the knowledge transfer and score the potential media accurately.

The team discussed criteria that would affect the decision of media selection, and the conclusion was that performance and cost were both important, while risk of knowledge spillover was negligible. Meanwhile, they thought that AHP was a proper evaluation method. Thereafter, they constructed a hierarchy, which is shown in Figure 2.

Following procedure of the decision model based on AHP, they began to discuss and compare criteria in each level below the objective of the hierarchy, in terms of their importance to a given criterion occupying the level immediately above the criteria being compared. The team thought that knowledge transfer performance was three times as important as knowledge transfer cost, and obtained Table 3. Similarly, they began to compare the importance of criteria below knowledge transfer performance and knowledge transfer cost, and got Table 4 and Table 5.

Then, the team compared the preference of the media alternatives to the criteria occupying the level immediately above these alternatives. Treating sending memos and descriptions as the base media, when the team compared the preference of the four media alternatives under the criterion of knowledge completeness, the team thought the preference of creating diagrams and manuals was two times as much as that of sending memos and descriptions, the preference of hiring consultants was three time, and the preference of worker rotation was eight times. Under the criterion of knowledge completeness, the team also compared the preference among creating diagrams and manuals, hiring consultants, and worker rotation directly. These results are presented in Table 6. Similarly, the team compared the preference of the media alternatives under other criteria, and got the Table 7 to Table 10.

The team then computed the priorities of each matrix and measured its consistency using software, and the results are shown in Table 11. For example, according to weights of the criteria, the team thought performance was more important than cost. Once all of the relative weights had been calculated, a composite weight for each alternative was determined by aggregating the weights over the hierarchy for each alternative. The results were (0.20, 0.19, 0.17, 0.43), and worker rotation was most preferred, which ultimately proved to be the most appropriate media.

Figure 2. Hierarchy of media selection in a tunnel project

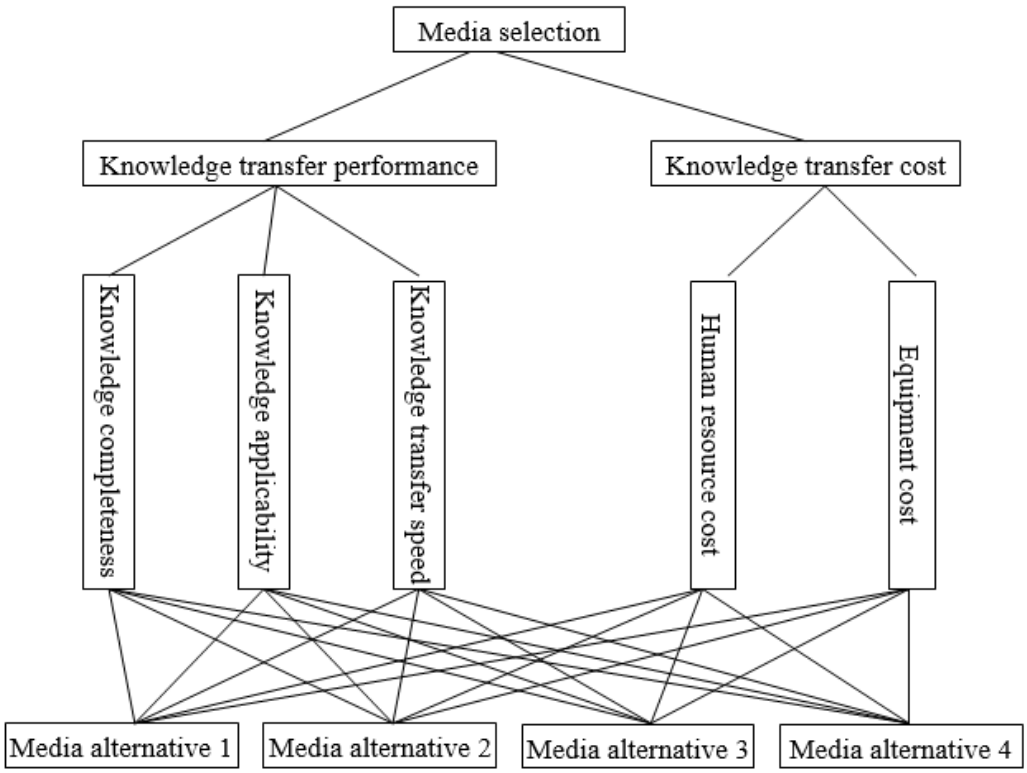


Table 3. Pairwise comparison square matrix of criteria below media selection

	Knowledge transfer performance	Knowledge transfer cost
Knowledge transfer performance	1	3
Knowledge transfer cost	1/3	1

Table 4. Pairwise comparison square matrix of criteria below knowledge transfer performance

	Knowledge completeness	Knowledge applicability	Knowledge transfer speed
Knowledge completeness	1	1	5
Knowledge applicability	1	1	5
Knowledge transfer speed	1/5	1/5	1

Table 5. Pairwise comparison square matrix of criteria below knowledge transfer cost

	Human resource cost	Equipment cost
Human resource cost	1	1/3
Equipment cost	3	1

Table 6. Pairwise comparison square matrix of alternatives below knowledge completeness

	Sending memos and descriptions	Creating diagrams and manuals	Hiring consultants	Worker rotation
Sending memos and descriptions	1	1/2	1/3	1/8
Creating diagrams and manuals	2	1	1/2	1/5
Hiring consultants	3	2	1	1/3
Worker rotation	8	5	3	1

Table 7. Pairwise comparison square matrix of alternatives below knowledge applicability

	Sending memos and descriptions	Creating diagrams and manuals	Hiring consultants	Worker rotation
Sending memos and descriptions	1	1/2	1/3	1/9
Creating diagrams and manuals	2	1	1/2	1/5
Hiring consultants	3	2	1	1/3
Worker rotation	9	5	3	1

Table 8. Pairwise comparison square matrix of alternatives below knowledge transfer speed

	Sending memos and descriptions	Creating diagrams and manuals	Hiring consultants	Worker rotation
Sending memos and descriptions	1	3	5	7
Creating diagrams and manuals	1/3	1	2	3
Hiring consultants	1/5	1/2	1	2
Worker rotation	1/7	1/3	1/2	1

Table 9. Pairwise comparison square matrix of alternatives below human resource cost

	Sending memos and descriptions	Creating diagrams and manuals	Hiring consultants	Worker rotation
Sending memos and descriptions	1	2	7	8
Creating diagrams and manuals	1/2	1	3	4
Hiring consultants	1/7	1/3	1	1
Worker rotation	1/8	1/4	1	1

Table 10. Pairwise comparison square matrix of alternatives below equipment cost

	Sending memos and descriptions	Creating diagrams and manuals	Hiring consultants	Worker rotation
Sending memos and descriptions	1	1	5	5
Creating diagrams and manuals	1	1	5	5
Hiring consultants	1/5	1/5	1	1
Worker rotation	1/5	1/5	1	1

In reality, however, the contractor selected sending memos and descriptions, creating diagrams and manuals, hiring consultants to give talks to the Boston crews, and worker rotation one by one, and the first three all failed. Fortunately, worker rotation ultimately successfully transferred the knowledge. The poor decision caused resource waste and time delay.

Comparing the decision based on our proposed decision model with the decision made by the contractor in reality, we find that our decision model is effective in media selection of knowledge transfer. The reason for the contractor's poor decision might have been because the contractor did not have explicit and comprehensive criteria for media selection as well as a proper evaluation method. They just made decision by intuition and paid too much attention to cost involved in knowledge transfer. If they were to have had the decision model put forward here, they might have selected the proper media at the beginning, which would have saved the contractor's money and time.

DISCUSSION AND CONCLUSION

Globalization strengthens the opportunities and challenges of knowledge transfer (Wang et al., 2017). As the development of information and communication technologies, media play an increasingly important role in knowledge transfer (Muhammad Wasim & Ali, 2017), and more attention should be paid to media selection in knowledge transfer. With a view of the sender or recipient, prior studies of media selection mainly focus on performance or cost aspect respectively and do not consciously pay attention to the risk of knowledge spillover. Thus, with a view of whole process of knowledge transfer, this paper develops a comprehensive framework of media selection from the performance, cost, and risk of knowledge spillover perspectives. In addition, the objectives of performance, cost reduction, and risk restraint often conflict when firms select media in knowledge transfer. Then, this paper constructs a decision model based on AHP to guide firms' media selection. At last, this paper reexamines a case that has been investigated by Davenport and Prusak (1998) to illustrate the effectiveness of the model in practice.

Theoretical Contributions

This study mainly contributes in the following aspects. First, this study constructs a framework to unify the influential theories of media choices and deepen the understanding of the relationship between media and knowledge transfer. Although media are important in knowledge transfer, existing studies mainly focus on their effects on one dimension of knowledge transfer objectives. This study suggests that knowledge transfer is a multi-objective project and deduces the mechanisms of media attributes influencing knowledge transfer objectives on the basis of the existing theories and literature.

Table 11. Results of priorities and consistencies

	Priorities	Consistency index
Criteria below media selection	0.75, 0.25	0
Criteria below knowledge transfer performance	0.45, 0.45, 0.09	0
Criteria below knowledge transfer cost	0.25, 0.75	0
Alternatives below knowledge completeness	0.07, 0.12, 0.21, 0.60	0.00374769
Alternatives below knowledge applicability	0.07, 0.12, 0.21, 0.60	0.00265148
Alternatives below knowledge transfer speed	0.59, 0.22, 0.12, 0.07	0.00639507
Alternatives below human resource cost	0.57, 0.27, 0.08, 0.07	0.00259406
Alternatives below equipment cost	0.42, 0.42, 0.08, 0.08	0

Second, this study proposes a decision model to facilitate media selection in knowledge transfer. Importance of knowledge transfer objectives is different and varies in different projects. Moreover, influences of different media on the knowledge transfer objectives are different. Thus, this study constructs a hierarchy of media selection in knowledge transfer to clarify the decision process and puts forward a decision model to aid media selection.

Third, this study can settle controversies of media selection in existing studies. Because existing studies about media selection mainly focus on the influences of one objective of knowledge transfer, the propositions and predictions sometimes are not accurate. For instance, if some media all can transfer knowledge successfully, the cost and risk factors should be added to explain the results of media selection. The framework developed in this study suggests the comprehensive factors influencing media selection and argues that their importance varies in different situations. As a result, the framework in this study has a stronger explanation capability and can settle controversies of media selection in existing studies.

Practical Implications

In practice, this paper has some managerial implications. First, this paper constructs the comprehensive criteria of media selection. With the comprehensive criteria, firms and media users can consider almost all factors influencing media selection from the objective perspective, not only cost and benefit but also risk of knowledge spillover. Therefore, they will not omit important factors when making decisions.

Second, this paper provides a decision model based on the criteria of media selection and AHP for firms to select media in their knowledge transfer projects. This model is especially useful when a firm face large knowledge transfer projects with multiple goals. Under this condition, the projects have a significant influence on the firm's survival and prosperity, and the firm should select media cautiously. Then, the decision model in this paper is particularly valuable for facilitating media selection of this kind.

Third, firms should enrich the media used for knowledge transfer. Media users and firms determine the importance of the knowledge transfer objectives, score the media in different objectives, and select the appropriate media in knowledge transfer. If there are only a few media available for media user and firms, media users' and firms' media choices are restrained, which might harm the knowledge transfer performance, raise the knowledge transfer cost, and aggravate risk of knowledge spillover. Thus, firms should take measures to add media, including traditional and new media, to expand the options of media in knowledge transfer.

Limitations and Future Research Directions

There are several research limitations and future research directions. First, this paper applies the decision model to a finished case, and applying it to an ongoing knowledge transfer project to test its effectiveness would be valuable. Second, it is interesting to investigate how the sender and the recipient bargain and come to an agreement about media selection since their objectives are not always consistent.

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