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# A measure of knowledge sharing behavior: scale development and validation

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**Abstract**
The concept of knowledge sharing is getting more and more attention in the research and practice of knowledge management. It is necessary to develop relevant performance assessment and reward systems to encourage people's knowledge sharing behaviors (KSBs). Till now, little effort has been put into developing a valid and reliable measure of KSB. The primary purpose of this study is to develop a new measure of KSB with desirable psychometric properties – a well-developed KSB scale with a sufficient level of reliability and validity. This main objective was achieved by using the following procedures: (1) specify domain of construct, (2) generate scale items, (3) purify scale, and (4) validate scale. The new KSB scale developed in this study is a 4-dimensional, 28-item, 5-response choice frequency scale. The scale includes written contributions, organizational communications, personal interactions, and communities of practices dimensions. The results provided evidence of the dimensionality, reliability, and validity of the KSB scale.
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## Introduction

Knowledge is regarded more and more as the critical resource of firms and economies (Quinn, 1992). It is considered a key part of the strategy to use knowledge and expertise to create a sustainable competitive advantage in today's business environment. This is why knowledge management has become very popular although the field is only about 10 years old.

Knowledge management is a very broad research area that could be explored from different aspects such as knowledge identification, creation, organization, storage, sharing, use, and maintenance. Among these aspects, knowledge sharing or knowledge transfer is becoming an increasingly popular area of interest to researchers, especially when the human factor of knowledge management is stressed (Dougherty, 1999; Hislop, 2003). How knowledge can best be shared as a corporate asset is a critical and challenging issue in knowledge management (Oh, 2000). Knowledge sharing links individuals and organizations by transferring knowledge from an individual to an organizational level, and hence it brings competitive value for the organization (Ipe, 2003).

### Research objectives

The concept of knowledge sharing is getting more and more attention in the research and practice of knowledge management because of its potential benefits to individuals and the organization. Thus, it is necessary to develop relevant performance assessment and reward systems to

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encourage people's KSBs. Otherwise, employees will focus on measurable performances rather than immeasurable performances like sharing knowledge and experience with others (Currie & Kerrin, 2003).

If managers of a company believe knowledge sharing is beneficial to both individuals and the organization and would like to reward KSBs, it is necessary to evaluate and measure the behaviors first. A challenge associated with setting up knowledge sharing rewards is the difficulty in identifying and evaluating the knowledge sharing (especially the tacit knowledge) at the individual level (Ipe, 2003; Michailova & Husted, 2003). For example, tracking the contribution to an online knowledge sharing system is relatively easy; however, monitoring whether knowledge sharing takes place socially in situations like face-to-face conversation is very difficult.

Till now, little effort has been put into developing a valid and reliable measure of KSB. The measurement of KSB is still such a new area that no definitive measure of it exists. Based on the literature review, mainly three methods were used in quantitative studies to measure employees' KSBs: number counting, just asking, and taxonomy based on knowledge/technology type. These methods remain problematic, as discussed below.

### *Number counting*

Huysman & de Wit (2002) argued that the need to measure often leads to the wrongly developed measurement. In the absence of good measuring tools, many companies use solutions such as counting the number of hits on personal postings, the number of documents submitted or consulted, the number of contributions to meetings, the number of written reports, the rate of contribution to knowledge data bases, the number of new ideas, the number of improvement suggestions made, the number of presentations made, etc. (Liebowitz, 2002; Smith & McKeen, 2003).

Obviously, computer-based knowledge sharing is relatively easier to track because an individual's contributions to knowledge bases or online discussions are readily observable. For instance, Samsung Life Insurance rewards employees for their contribution to the knowledge sharing system through the design of a point system (Moon & Park, 2002). Using a point redemption system, the company awards points for knowledge flow each year. Each time an employee logs into the system, 10 points are given. Two hundred points are additionally granted for creating knowledge material and one point each for a content search. The reward points can be redeemed to go on overseas training or used as cash-in opportunities or accounts for 10% of an employee's bonus. Also the company nominated 'knowledge masters.'

However, these measures result in an emphasis on the product approach to knowledge, while the process approach is ignored (Huysman & de Wit, 2002). Other forms of knowledge sharing such as those taking place through informal conversations and personal networks are not considered, which might have greater impact on organizational performance. How frequently or how well employees share knowledge cannot easily and correctly be measured just by the number of 'posts' in a knowledge base (Harvard, 1997). The communication of informal interaction is important but not usually recorded so the contributions are difficult to evaluate.

### *Just asking*

Some empirical studies assessed KSB by simply asking people's perception of the degree of knowledge sharing in different scenarios, such as the studies of Zarraga & Bonache (2003) and Kamdar *et al*. (2004).

For instance, in Chow *et al*.'s (2000) experimental design to test the effects of national culture on level of knowledge sharing, KSB is measured by three scenarios describing day-to-day operation stories. Participants (middle-level managers) were asked to assess the extent to which a typical employee in their firm would reveal a past personal job-related mistake, ask a clarifying question, or express a contrary or challenging opinion in the context of a meeting.

Without discussing whether knowledge sharing scenarios are appropriate to evaluate KSB, this method is impossible to apply as an assessment tool in any job performance evaluation system. Its use is limited to research.

### *Taxonomy based on knowledge type or technology type*

Some researchers assess KSB according to different taxonomies based on different knowledge types or technology types. Bock & Kim (2002) measured KSB by asking participants how frequently they share different knowledge (reports, official documents, manuals, methodologies, models, experience, know-how, know-where, know-whom, and expertise from education and training) with other members, and how frequently they use different information technology (bulletin board, e-mail, Webpage, chat room, e-document management system, and knowledge repository) to share their knowledge.

Cummings (2001) proposed a similar method to measure KSB: asking participants how often they shared each kind of knowledge (general overview, specific requirements, analytical techniques, progress reports, and project results) with group members or non-group employees inside the company. Likewise, Lee (2001) and Lin & Lee (2004) measured KSB by asking if employees in the company share know-how from work experience, share expertise from education and training, share business knowledge obtained informally (e.g., new stories, gossip) or from partners, etc.

The KSB taxonomy based on various knowledge types or types of technology used to obtain the knowledge is problematic. The argument in this research is that the knowledge or technology dimensions do not constitute different behaviors. To measure KSB, the questions should be about different kinds of KSBs by individuals in an organization.

The primary purpose of this study is to develop a new measure of KSB with desirable psychometric properties – a well-developed scale with a sufficient level of reliability and validity. This objective will be achieved by identifying the construct of KSB and categorizing different behaviors, developing the scale for each category, and empirically testing the scale's validity and reliability.

### Research significance

Doing research on the measurement of KSB will make a significant contribution to the development of effective means of knowledge sharing. First, as noted above, little attention has been paid to the creation of a valid and reliable measurement instrument of KSB. The currently available instruments are questionable. A commonly existing problem in academic areas is, as Schwab (1980) argued, that measures are often used to empirically examine a hypothesized relationship between variables without adequate data supporting their reliability and validity. This problem causes difficulties in interpreting whether a statistical finding is believable or not because the measures may generate invalid data (Churchill, 1979; Hinkin, 1995). This study can contribute to the development and validation of a new scale of KSB with assured accuracy of measurement, which can be used as an instrument in relationships research related to KSB in the future field studies conducted by researchers.

Second, up till now, not much effort has been made to overcome performance evaluation issues relevant to knowledge sharing in organizations. If an organization wants to encourage people's KSB, KSB should be explicitly recognized as part of the individual performance domain and should be linked to performance appraisal practices. This study could help support the design and development of an effective performance evaluation system to successfully facilitate knowledge sharing activities.

### Research outline

A new scale of KSB was designed following typical procedures of scale development (Churchill, 1979; Spector, 1992), with some revisions. Specifically, this study involved four major steps (presented in Figure 1): (1) specify domain of construct: defining the construct clearly and precisely based on the literature, and proposing a new taxonomy of the construct based on the literature; (2) generate scale items: using a combination of deductive and inductive approaches to develop an item pool (multiple-item scales) to measure different dimensions of the construct, then asking experts to evaluate face and content validity of the scale; (3) purify scale: collecting empirical data to pre-test reliability and factor structure (scale dimensionality) of the scale; and (4) validate scale: providing new empirical data to assess this new scale's validity and reliability.

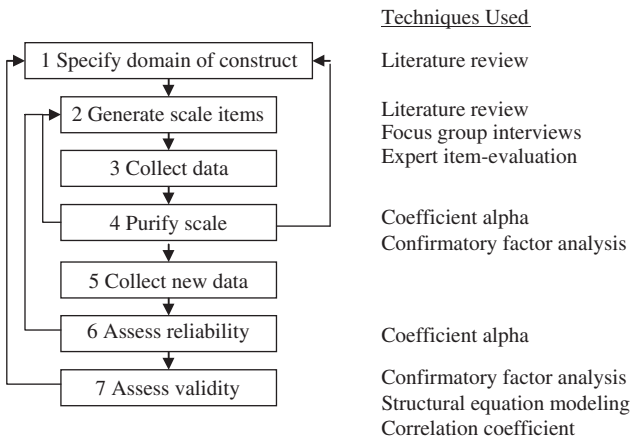


**Figure 1** Procedures for developing a measure of KSB.

## Specify domain of the construct

### A definition of KSB

Knowledge could be shared at individual, unit or group, and organizational levels, within or across organizations (Ipe, 2003). This study focuses on the analysis of knowledge sharing at the individual level within an organization because knowledge sharing fundamentally takes place between individuals. Some research refers to knowledge sharing as the attitude or ability to share knowledge. In other research, knowledge sharing may mean KSB, or the term may mean both the ability to share knowledge and the action of sharing it. This study focuses on the KSB of individuals because the behavior is what an organization wants to evaluate, measure, and integrate into its performance evaluation system.

A scale cannot be developed to measure a construct unless the nature of that construct is clearly described. Without a well-defined construct, it is difficult to write good items and to validate the scale (Spector, 1992). The relevant literature demonstrated that there is no clearly defined KSB concept. The current definitions do not meet the criteria for a good definition of a construct and they are weak in at least one of the following criteria: specification of a common theme, use of unambiguous terms, contribution to overall understanding of the concept, and clear distinction from related concepts (Podsakoff, 2003). Some examples of KSB definitions are given below.

> Knowledge sharing is defined as activities of transferring or disseminating knowledge from one person, group or organization to another. (Lee, 2001, p. 324)

> People who share a common purpose and experience similar problems come together to exchange ideas and information. (MacNeil, 2003, p. 299)

> Knowledge sharing is basically the act of making knowledge available to others within the organization. (Ipe, 2003, p. 32)

> Knowledge sharing is the behavior of disseminating one's acquired knowledge with other members within one's organization. (Ryu *et al.*, 2003, p. 113)

> Knowledge sharing refers to the degree to which one actually shares knowledge with others. (Bock & Kim, 2002, p. 16; Lin & Lee, 2004, p. 115)

In this study a clearly defined new construct of KSB is proposed, which guides the subsequent scale development in this study.

> Knowledge sharing behavior is a set of *individual* behaviors involving *sharing* one's *work-related knowledge and expertise* with other members *within* one's organization, which can *contribute* to the ultimate effectiveness of the organization.

#### *Individual behaviors*

Sharing of knowledge may occur at various levels in organizations such as at the individual, team, or department level, or at the level of the organization as a whole (Erhardt, 2003), but it starts with the individual (Gurteen, 1999). It relies on the behavioral choice of individuals (Dougherty, 1999). Therefore, this definition confines KSB to the individual level within an organization.

#### *Sharing*

Sharing here means the action moves from knowledge provider to knowledge recipient and does not include two-way knowledge exchanges between knowledge provider and knowledge recipient which are defined as knowledge transfer or knowledge flow (Szulanski, 1996). In other words, KSB is limited to the behavior of knowledge providers, not the behavior of knowledge receivers. A knowledge provider's KSB is the performance that an organization wants to evaluate and reward.

#### *Work-related knowledge and expertise*

The knowledge that people share formally or informally is relevant to tasks performed. It is not only information-based or know-what knowledge. More important, it is know-how, know-why, experiences, ideas, skills, and expertise. The latter kind of knowledge is more tacit and harder to share, and it is constructed through social relationships and interactions. Therefore, knowledge here is defined as 'the explicit job-related information and implicit skills and experiences necessary to carry out tasks' (Kubo *et al*., 2001, p. 467).

#### *Within one's organization*

The KSB here refers to the behaviors that occur within one's organization, but not to inter-organizational knowledge sharing. Yet KSB could occur either within or between different teams, departments, or divisions.

#### *Contribute to the organization*

The KSB that occurs can bring value-added benefits to the organization and contribute to the ultimate effectiveness of the organization. Knowledge sharing can ultimately increase productivity, improve the work process, create new business opportunities, and help the organization to achieve its performance objectives.

#### *Differences between KSB and other related concepts*

There are some differences between KSB and other related organizational behavior concepts such as organizational citizenship behavior (OCB). As defined by Organ (1988), 'OCB represents individual behavior that is discretionary, not directly or explicitly recognized by the formal reward system, and that in the aggregate promotes the effective functioning of the organization' (p. 4). The behavioral contents of OCB include helping, volunteering, persisting with extra effort, following rules, no complaining, etc.

KSB and OCB are similar in some aspects. All of the behaviors can contribute to organizational successes such as productivity, efficiency, innovation, and retention of productive employees, though there is no direct effect on financial performance (Motowidlo, 2000). Since the behaviors described under these terms are beyond what is required for jobs, they may not be explicitly captured by an organization's performance management system. The rewards for the contribution may be indirect or uncertain, as compared to more formal contributions related to task performance.

KSB is different from OCB for two reasons. First, the concept of OCB is broader than the concept of KSB. It refers to 'all actions an organization would like to see their employees to perform but cannot require them to perform' (Motowidlo, 2000, p. 119). In other words, it refers to all behaviors except task performance. In contrast, KSB specifically refers to behaviors of sharing work-related knowledge and expertise, occurring either formally, in cases like a discussion in a meeting, or informally, in cases like a conversation in the hallway.

Second, an individual's decision about whether to share knowledge or not can be influenced by perceived benefits and costs of sharing. This is supported by the empirical data of Kamdar *et al*.'s (2004) experimental study on the relationship between OCB and KSB. The authors assumed that since sharing knowledge with co-workers enhances general productivity and is discretionary, it might be regarded as a form of OCB – a form of altruism or helping. Yet their findings showed no strong relationship between KSB and OCB ratings. They indicated that unlike forms of OCB, knowledge sharing requires a thorough cost–benefit analysis on the part of the employee. KSB requires that people be willing to give up the 'secret of fire' for the benefit of themselves, co-workers, the work unit, or the organization. This distinction can explain the varying relation between KSB and OCB.

### Taxonomy of KSB

KSB is a difficult concept to define and measure. The measurement of KSB is still a very new practice. In order to design a new instrument to measure KSB, first it is necessary to examine the possible subsets of KSB. Particularly, the KSB categories classified in this study, based on the literature, are similar to the four major mechanisms or modes for individuals to share their knowledge in organizations identified by Bartol & Srivastava (2002): 'contribution of knowledge to

organizational database, sharing knowledge in formal interactions within or across teams or work units, sharing knowledge in informal interactions, and sharing knowledge within communities of practice' (p. 65).

Bartol and Srivastava's classification is consistent with Hansen *et al*.'s (1999) statement that there are two major knowledge management strategies used in companies: codification strategy and personalization strategy. While knowledge contribution to a database falls under the codification strategy, the other three dimensions belong to the personalization strategy (Bartol & Srivastava, 2002). The four subsets of KSB proposed in this study are written contributions (WC), organizational communications (OC), personal interactions (PI), and communities of practice (CP).

### *Written contributions*

This dimension of KSB includes behaviors of employees' contributing their ideas, information, and expertise through written documentation rather than dialogs, such as by posting ideas to organizational database and submitting reports which can benefit other employees and the organization. Knowledge is shared through a person-to-document channel. Codification strategy of knowledge management and sharing of explicit knowledge are emphasized for this type of knowledge sharing.

Bartol & Srivastava (2002) argued that knowledge contribution to a database is easily associated to rewards relevant to KSBs. The reason is that the contributions to the knowledge databases can be easily tracked, accessed, evaluated, and recorded, so employees are sure their knowledge sharing will not be ignored or devalued by the organization and therefore it will definitely be rewarded later. Thus, it is likely that the extrinsic motivation for sharing knowledge is generally high because knowledge sharing is perceived to be externally controlled (Kaser & Miles, 2001). Therefore, specifying the benefits of sharing knowledge in the incentive system is a useful means of promoting this type of KSB. Possible individual rewards for knowledge sharing could be either pay-based or recognition-based.

### *Organizational communications*

This dimension of KSB includes behaviors of sharing knowledge in formal interactions within or across teams or work units. For example, working teams or project groups may have regular meetings for brainstorming or problem solving by seeking ideas from employees. Knowledge is shared through formal social interactions of a person-to-group channel. Personalization strategy of knowledge management and sharing of tacit knowledge through formal face-to-face conversation are stressed for this type of knowledge sharing.

This subset of KSB is motivated by employees' willingness to contribute to the success of team and organization. In this situation, employees believe through knowledge sharing they can help the organization as a whole meet its business objectives, but not for their self-interests (Gurteen, 1999). Employees may believe that their contributions will be valuable to the organization, give themselves positive feelings of sociability or doing the right thing, or promote personal responsibility (Cabrera & Cabrera, 2002). Organizational commitment can positively affect employees' attitudes and behaviors of knowledge sharing (Hislop, 2003; MacNeil, 2003).

Since this type of KSB occurs in more formalized routines like formal meetings or workshops, the social interactions such as discussions in meetings or presentations in seminars are easily noticed and remembered by supervisors and colleagues. Thus, the behaviors are more likely to be considered and rewarded through a company's incentive systems. Rewards at different levels (individual rewards, rewards based on team performance, profit or gain sharing plans across teams) may enhance individual knowledge sharing within or across teams (Bartol & Srivastava, 2002).

### *Personal interactions*

This dimension of KSB includes behaviors of sharing knowledge in informal interactions among individuals, such as chatting over lunch and helping other employees who approach them. Knowledge is shared through the informal social interactions of a person-to-person channel. The personalization strategy of knowledge management and the sharing of tacit knowledge through informal conversation are highlighted for this type of knowledge sharing.

This subset of KSB involves absolutely voluntary and natural behaviors. The aim of helping and assisting is to help other employees with specific problems, to help them work better and more efficiently, to help them avoid risks or trouble, or to let others share their genuine passion and excitement on some specific subject. Obviously, the larger the personal networks and the better the personal relationships an individual has, the greater the chance that the individual will share knowledge with people he or she knows in his or her social networks (Kubo *et al*., 2001).

The intrinsic motivation of this type of KSB is high because the sharers perceive knowledge sharing as self-determined (Kaser & Miles, 2001). These informal social interactions, like chatting at lunchtime, are hard for the organization to notice and evaluate. Therefore, as Bartol & Srivastava (2002) noticed, the rewarding of this type of KSB will be less effective than the rewarding of the first two types. They further suggested procedural and distributive fairness of rewards by managers could convey a signal to employees that the organization values them and is trustworthy, which in turn may have a positive impact on employees' KSBs.

### *Communities of practice*

This dimension of KSB includes behaviors of sharing knowledge within CP, which are voluntary groups of employees communicating around a topic with common interests in a non-routine and personal way, as previously described. Knowledge is shared through informal social

interactions of a person-to-group channel. The personalization strategy of knowledge management and sharing of tacit knowledge through informal conversation are emphasized for this type of knowledge sharing.

This subset of KSB is composed of primarily voluntary and natural behaviors based on the general expectation of reciprocity. Kaser & Miles (2001) called this behavior social exchange relationship-based behavior (a social exchange relationship is reciprocal acts in which individuals offer help to one another). Social exchange relationship-based behavior happens where there are common areas of interest, shared passion, specific shared problems. It is used in establishing group identity and shared perception of value (e.g., both parties know this knowledge has real potential value). An individual shares his or her knowledge expecting reciprocity, which is based on the trust that others will also share their knowledge.

The intrinsic motivation of this type of KSB is high. Although this type of KSB may be supported by an organization, it does not need to be specified and valued by the organization (Kaser & Miles, 2001). Therefore, as Bartol & Srivastava (2002) hypothesized, 'intrinsic rewards that build expertise and feelings of competence are more appropriate for influencing knowledge sharing within organizational communities of practice' (p. 72). For example, the World Bank encourages knowledge sharing by increasing intrinsic motivation of community members such as the opportunity to work on interesting ideas and building relationships with colleagues (Bartol & Srivastava, 2002).

A summary and comparison of the above four subsets of KSB is shown in Table 1.

## Generation of initial item pool

### Study 1: Item generation

There are two basic approaches for item generation: deductive ('logical partitioning,' 'classification from above') or inductive ('grouping,' 'classification from below') approaches (Hinkin, 1995). Deductive scale development method requires a thorough review of literature and a clear understanding of constructs, while inductive scale development method is used when little theory could be used to identify constructs requiring items to be generated by asking a sample of respondents to provide descriptions relevant to studied constructs. In this study both approaches are used for item generation.

First, on the basis of the thorough literature review of existing theoretical and empirical research, an initial item pool was generated. Since the concept of KSB is multidimensional, four subsets of items were tentatively developed to tap each of the four dimensions of the construct: WC, OC, PI, and CP.

In addition, an inductive scale development approach, specifically a focus group interview, was conducted to confirm the re-conceptualization of the definition and categories of KSB, to uncover dimensions of behavior not yet recognized in the literature, and to help generate additional items of KSBs. A 2-h semi-structured focus group interview was conducted with five practitioners from different industries whose work is relevant to the knowledge management area. Responses were then classified into a number of categories by content analysis based on key words or themes.

The KSB items were then written to correspond to categories proposed according to the analysis of literature review and focus group interview results. The product was the knowledge sharing behavior scale (KSBS) initial item pool comprising 32 items to capture the domain of KSB. The initially created KSBS is a 4-dimensional, 32-item, 5-response choice frequency scale.

### Study 2: Evaluation of items

Once the item pool of KSBS is generated, what is needed next is to examine how well the items of the construct

**Table 1 Comparison of four KSB subsets**

| | *Written contributions* | *Organizational communications* | *Personal interactions* | *Communities of practice* |
|---|---|---|---|---|
| Channel | Person-to-document, for example, post ideas to online database | Person-to-group (social, formal), for example, brainstorming meetings | Person-to-person (social, informal), for example, face-to-face talk over lunch | Person-to-group (social, informal), for example, meet with community members to discuss problems |
| Motivation | Extrinsic: high<br>Intrinsic: moderate | Extrinsic: high<br>Intrinsic: moderate | Extrinsic: low<br>Intrinsic: high | Extrinsic: moderate<br>Intrinsic: high |
| Rewarding strategy | Individual rewards | Rewards at both individual and team levels | Procedural and distributive fairness of rewards | Intrinsic rewards such as building relationship with colleagues |
| Affecting factors | Knowledge sharing rewards | Commitment to the organization | Personal networks and relationships | Trust between two parties |
| Knowledge shared | More explicit | More tacit | More tacit | More tacit |
| Knowledge management strategy | Codification strategy | Personalization strategy | Personalization strategy | Personalization strategy |

tap into its conceptual domain (Podsakoff, 2003). The purpose of item-evaluation in this stage is to analyze both the face validity of the items and the content validity of the measure. Five knowledge management experts in the United States, who are familiar with the knowledge sharing context, were invited to review the initial 32 items and evaluate both face validity and content validity of the KSBS.

Face validity refers to whether an item, on its face, appears to measure the construct (Podsakoff, 2003). Overall, the five experts reported that the items have face validity because they looked good, appropriate, and clear.

Content validity refers to whether items used adequately tap into the construct's domain of interest (Hinkin, 1995), that is, the extent to which a specific set of items reflects a content domain. The measure should be neither deficient (having too few items) nor contaminated (having too many items). A matrix method (Podsakoff, 2003) reporting the relationship between items and dimensions of the construct was adopted to evaluate content validity of KSBS. Knowledge management experts were asked to classify the randomly ordered items into one of several categories (KSB dimensions plus an 'other' dimension). The items that are assigned to the proper category with a high percentage (e.g., 80% – four out of five experts) of the time by the experts will be retained for further analysis.

The experts evaluated whether each item tapped into each dimension or component through the matrix method. Among the items, 27 of them were assigned to the proper category with 80% or higher by the experts. The remaining five items were either deleted or reassigned to another category, to make sure the measure was not deficient or contaminated. Therefore, the revised KSBS is a 4-dimensional, 28-item, 5-response choice frequency scale (see Appendix).

## Scale purification (study 3)

The third step in developing a measure of KSB was to do a pilot study to refine the KSBS. The pilot study provides information about deficiencies and suggestions for improving the measure through the examination of measurement model type, internal consistency reliability, and factor structure (scale dimensionality) of the KSBS.

The KSBS was pre-tested using a convenience sample of 212 subjects, including about 120 distance MBA students and 92 employees working in companies. The distance MBA students were from two large mid-west universities. MBA students were readily available. They can be regarded as a sample of the ultimate population for which the KSBS is intended because they were all full-time employees while studying in part-time MBA programs. The 92 employees were working in relatively large companies where they needed to share knowledge and information in their day-to-day work. The data were collected by online survey. One thing to mention is that there was no missing value problem because in the online survey that was used to collect data, every question had to be answered in order to successfully submit the completed survey. All analyses below of this pilot study were conducted through SAS 9.13 version distributed by SAS Institute.

### Formative *vs* reflective indicators

Classical test theory (e.g., Nunnally, 1978; Churchill, 1979) assumes that the underlying latent construct or variable causes the observed indicators or items in the measure. So the assumption of the measurement model is that the direction of causality is from the latent variable to its indicators. However, researchers (Bollen & Lennox, 1991; MacCallum & Browne, 1993; Diamantopoulos, 1999; Diamantopoulos & Winklhofer, 2001; Jarvis *et al*., 2003) found that this is not always true. For some constructs, it makes more sense conceptually to view the direction of causality from the indicators to the latent variable.

An example is a social interaction construct measured by indicators of time spent with spouse, with co-workers, with friends, and with others (Bollen & Lennox, 1991): if time spent with spouse increases, the social interaction increases even if time spent with co-workers, with friends, and with others does not change; however, an increase of social interaction does not require a simultaneous increase in all four indicators.

Therefore, the observed indicators can be either reflective (effect) or formative (cause). Jarvis *et al*. (2003) developed a set of conceptual criteria that can be used to determine whether a construct should be modeled as having formative or reflective indicators. The major differences between formative and reflective measurement models are shown in Table 2.

While reflective indicators are typical of classical test theory and factor analysis models, formative indicator models do not need to conform to the conventional guidelines, like the claim that construct indicators should be internally consistent and items with low item-to-total correlations should be dropped (Bollen & Lennox, 1991). Jarvis *et al*. (2003) pointed out that the choice between formative and reflective models can substantially influence estimation procedures, and the misspecification of the direction of causality between a construct and its indicators can lead to inaccurate conclusions about the structural relationships between constructs.

To decide whether a construct is formative or reflective in nature, it is important to have a clear conceptual definition of the construct, generate indicators which can fully represent the domain of the construct, and consider the causality relationship between the construct and its indicators carefully. The judgment can be made based on the difference (Table 2) proposed by Jarvis *et al*. (2003).

In this study, the subscales 'Written Contributions' and 'Personal Interactions' were identified as formative models because the direction of causality can be viewed as from indicators to construct. Indicators are not expected to be correlated and a change in the construct

**Table 2 Summary of differences between types of measurement models (Jarvis *et al.*, 2003)**

| *Formative model* | *Reflective model* |
|---|---|
| Direction of causality is from indicators to construct | Direction of causality is from construct to indicators |
| A change in the construct does not implicate changes in all indicators | A change in the construct causes changes in all indicators |
| No reason to expect the indicators are correlated (internal consistency reliability is not implied) | Indicators expected to be correlated (should possess internal consistency reliability) |
| Indicators are defining characteristics of the construct | Indicators are manifestations of the construct |
| Dropping an indicator from the measurement model may alter the meaning of the construct | Dropping an indicator from the measurement model does not alter the meaning of the construct |
| Takes measurement error into account at the construct level | Takes measurement error into account at the item level |

does not implicate changes in all indicators. For instance, the WC subscale is measured by indicators of documents submission, paper publication, sharing of personal files, online database contribution, etc. All these items are different activities contributing to written contribution behaviors (heterogeneity of the items of the same construct); and if personal file sharing behavior increases, the WC increases even if other items do not change.

On the contrary, the subscales 'Organizational Communications' and 'Communities of Practice' were identified as traditional reflective models since the direction of causality can be viewed as from construct to indicators. Indicators are expected to be correlated with each other and a change in the construct causes changes in all indicators. For example, CP subscale is measured by indicators that all describe activities within a community of practice. The items are different activities but all relevant and most of them usually happen simultaneously (homogeneity of the items of the same construct). In other words, an increase of CP usually causes a simultaneous increase in all items.

It is obvious that KSBS is a formative scale since the four subscales are quite different dimensions contributing to the KSBS. In other words, the KSBS is a formative/reflective first-order, then formative second-order scale. Figure 2 shows the KSBS model specifications.

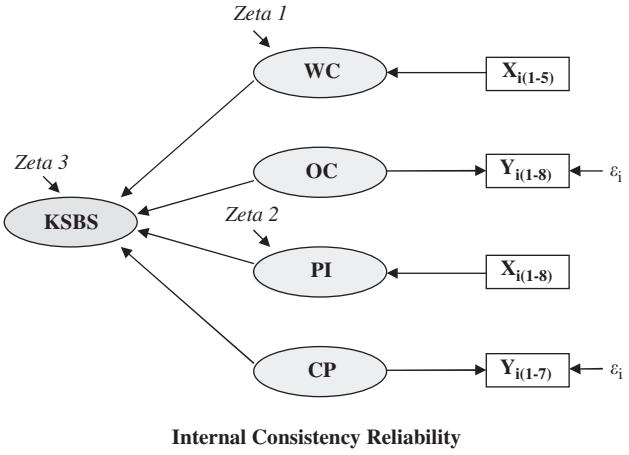


**Figure 2** KSBS model specifications.

## Internal consistency reliability

Internal consistency reliability refers to the extent to which items intercorrelate with one another. Internal consistency implies that multiple items measure the same construct, and intercorrelate with one another. In contrast, low inter-item correlations indicate that some items are not drawn from the appropriate domain and produce unreliability (Churchill, 1979).

The commonly accepted measure of internal consistency reliability is Cronbach's coefficient alpha. Nunnally (1978) suggested that an alpha of 0.70 be the minimum acceptable standard for demonstrating internal consistency. As shown in Table 3, the reliability values of OC and CP are 0.915 and 0.939, respectively, which indicate the items perform very well in terms of OC and CP reliability. Furthermore, subsequent item-to-total correlations were also calculated for suggested elimination of individual item. Generally an item–total correlation over 0.40 is acceptable. For all items in OC and CP, their item–total correlations achieved were greater than 0.58, which means that no item needs to be eliminated.

However, as discussed previously, if indicators are formative rather than reflective, high internal consistency reliability is not necessarily expected because of the heterogeneity of the indicators of the same construct. The relationships between the indicators can be positive, negative, or no correlation (Bollen & Lennox, 1991). And it is necessary to be very cautious when removing an item of a formative scale because omitting an item is omitting a part of the construct. As shown in Table 3, the reliability values of WC and PI were 0.506 and 0.710, respectively. The overall KSBS reliability was 0.73 as calculated. Additionally, almost all item–total correlations of WC and PI items represented were lower than 0.50.

## Factor structure (scale dimensionality)

Factor analysis can be used to suggest and confirm scale dimensionality. Both exploratory and confirmatory factor analysis (CFA) in scale construction aim to examine the stability of the factor structure and provide information that will facilitate the refinement of a new measure

**Table 3 Pilot-study KSBS internal consistency reliability and intercorrelations**

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Written contributions (WC) | (0.506) | 0.443* | 0.417* | 0.433* |
| 2. Organizational communications (OC) | | (0.915) | 0.516* | 0.423* |
| 3. Personal interactions (PI) | | | (0.710) | 0.427* |
| 4. Communities of practice (CP) | | | | (0.939) |

*Note*: $N = 212$, coefficient alpha on the diagonal, $^*P < 0.0001$, one-tailed.

**Table 4 Pilot-study model-fit indices**

| | *Chi-square* | *d.f.* | *P (close)* | *RMSEA* | *CFI* | *NFI* | *NNFI* | *GFI* | *RMR* |
|---|---|---|---|---|---|---|---|---|---|
| Two-factor model (OC and CP) | 270.90 | 89 | 0.00 | 0.098 | 0.930 | 0.901 | 0.918 | 0.857 | 0.050 |
| Two-factor model (WC and PI) | 200.70 | 64 | 0.00 | 0.100 | 0.763 | 0.693 | 0.711 | 0.866 | 0.103 |
| Four-factor model | 770.89 | 344 | 0.00 | 0.076 | 0.874 | 0.796 | 0.862 | 0.784 | 0.088 |
| Null model | 3788.69 | 350 | 0.00 | 0.215 | −0.008 | 0.000 | −0.088 | 0.255 | 0.274 |

*Note*: $N = 212$, RMSEA = root mean square error of approximation, CFI = comparative fit index (Bentler), NFI = normed fit index (Bentler and Bonett), NNFI = non-normed fit index (Bentler and Bonett), GFI = goodness-of-fit index, RMR = root mean square residual.

(Hinkin, 1995). He argued that while exploratory factor analysis allows the elimination of obviously poorly loading items (used to determine the number of components), the advantage of CFA is that it allows more precision in evaluating the measurement model (used to test a hypothesized structure). Therefore, in this study CFA is an appropriate method to be used to validate that the items empirically form the intended subscales (factors) because the factors and indicators have been hypothesized according to sufficient theoretical basis.

For reflective indicator models, CFA was conducted with the 212 observations of the sample to determine the fit of the measurement model to the data. Several fit indices are used to separately evaluate and compare across the CFA models. For formative indicator models, the situation is more complicated. There is little research providing guidance on how to verify formative indicator models in structural equation modeling (SEM). As Bollen & Lennox (1991) noticed, because the latent construct is a linear combination of its indicators and a disturbance, whether the model is good or not cannot be judged from its item covariances. The causal indicator model in isolation is statistically underidentified. Only when consequences of the latent construct are included can the formative indicator model be estimated. More will be discussed in study 4.

Specifically, the PROC CALIS program distributed by the SAS Institute was used and maximum likelihood estimation procedures were employed to conduct CFA to assess the quality of the factor structure (the fit between model and data). The process of determining if the model fits the data begins by reviewing overall goodness-of-fit indices and more detailed assessment of fit indices (Hatcher, 1994), as illustrated in the following three steps.

*Step 1: Reviewing the chi-square test.*
The chi-square test provides a statistical test of the null hypothesis that the model fits the data. If the model provides a good fit, the chi-square value will be relatively small, and the corresponding *P* value will be relatively large (above 0.05 and preferably closer to 1.00). However, with large samples and real-world data, the chi-square statistic is very frequently significant even if the model provides a good fit.

The chi-square test results were presented in Table 4. Several models are examined by CFA: a two-factor reflective model for OC and CP subscales, a two-factor formative model for WC and PI subscales, a four-factor model with all four factors of KSBS, and a null model where all items load on separate factors. All of these four models had large chi-square values and very small *P* values. As stated above, the chi-square test is frequently not valid and further goodness-of-fit indices are necessary to examine the model fit with the data.

*Step 2: Reviewing goodness-of-fit indices.*
Major overall model-fit indices considered include the comparative fit index (CFI), the normed fit index (NFI), the non-normed fit index (NNFI), and goodness-of-fit index (GFI). Values over 0.90 on these indices indicate an acceptable fit. The fit indices of four models were compared in Table 4. Obviously the best fit was from the first model – the two-factor reflective model for OC and CP subscales. All values were over 0.90 (except for the GFI that was close to 0.90) which indicates good model fit. The values (all lower than 0.90) of the second model – the two-factor formative model for WC and PI subscales – support our model type assumptions and indicate that a formative model might be more appropriate. The four-factor model and null model demonstrate poor fits of the data to the model.

In addition, root mean square error of approximation (RMSEA) and root mean square residual (RMR) measuring

discrepancies between the implied and observed covariance matrices are provided to assess the overall fit. Values of 0.10 or less indicate an acceptable fit. For two-factor reflective model for OC and CP subscales, RMSEA and RMR values were 0.098 and 0.050, respectively, which indicate an adequate fit. The RMSEA and RMR values of two-factor formative model and null model all show poor fits.

*Step 3: Reviewing significant tests for factor loadings*.
The factor loading is equivalent to a path coefficient from a latent factor to an indicator variable. A non-significant factor loading means that the involved indicator variable is not doing a good job of measuring the underlying factor, and should possibly be reassigned or dropped. The values of factor loading, standard error, and t value are presented in Table 5. All t values for OC and CP factors were over 3.291 which means a significant factor loading at $P<0.001$. And all factor loading coefficients were over or close to 0.60. Thus, it indicated that all items of OC and CP factors are doing a good job of measuring the underlying factor and there is no need to eliminate any items. All t values for WC and PI were over 1.96, and most factor loading coefficients were lower than 0.60 which also suggested a reflective model is not appropriate for WC and PI factors.

**Table 5 Pilot-study factor loading tests**

| *Item* | *Factor loading* | *Designated factor* | *SE* | *t Value* |
|---|---|---|---|---|
| 1 | 0.298 | WC | 0.077 | 3.83 |
| 2 | 0.321 | WC | 0.076 | 4.20 |
| 3 | 0.557 | WC | 0.103 | 5.37 |
| 4 | 0.736 | WC | 0.106 | 6.88 |
| 5 | 0.243 | WC | 0.083 | 2.92 |
| 6 | 0.627 | OC | 0.046 | 13.52 |
| 7 | 0.818 | OC | 0.055 | 14.85 |
| 8 | 0.769 | OC | 0.045 | 16.80 |
| 9 | 0.593 | OC | 0.044 | 13.20 |
| 10 | 0.601 | OC | 0.045 | 13.15 |
| 11 | 0.668 | OC | 0.057 | 11.65 |
| 12 | 0.679 | OC | 0.060 | 11.24 |
| 13 | 0.550 | OC | 0.058 | 9.37 |
| 14 | 0.311 | PI | 0.066 | 4.71 |
| 15 | 0.483 | PI | 0.078 | 6.20 |
| 16 | 0.403 | PI | 0.044 | 9.08 |
| 17 | 0.496 | PI | 0.045 | 10.91 |
| 18 | 0.613 | PI | 0.045 | 13.58 |
| 19 | 0.568 | PI | 0.042 | 13.41 |
| 20 | 0.170 | PI | 0.097 | 1.75 |
| 21 | 0.191 | PI | 0.066 | 2.88 |
| 22 | 0.885 | CP | 0.050 | 17.50 |
| 23 | 0.906 | CP | 0.049 | 18.18 |
| 24 | 0.911 | CP | 0.050 | 18.09 |
| 25 | 0.882 | CP | 0.050 | 17.48 |
| 26 | 0.773 | CP | 0.059 | 13.03 |
| 27 | 0.659 | CP | 0.063 | 10.33 |
| 28 | 0.669 | CP | 0.061 | 10.87 |

## Scale reliability and validity (study 4)

The fourth and last step in developing a measure of KSB was to collect new empirical data to examine the internal consistency reliability, factor structure, and construct (convergent and discriminant) validity of the KSBS.

The sample consisted of 196 employees working in a large U.S. high technology company. High technology firms belong to knowledge intensive companies. The company's success depends on developing and applying employees' knowledge and expertise to solve problems, generate ideas, or create new products and services. The sampling method used was random sampling: the online survey Web address was distributed to several units of the company located in the United States to invite employees who need knowledge sharing in their daily work to participate. It took about 2 months to receive 196 responses, and the response rate was about 20%. The data was collected through an online survey. There was no missing data because every question of the survey had to be answered in order to submit the completed survey. All analyses below of study 4 were conducted through SAS 8.0 version distributed by SAS Institute.

### Reliability assessment

The same as the method of reliability testing described in study 3, for traditional reflective scales, internal consistency reliability was measured again with new data collected through Cronbach's coefficient alpha to see if the scale is internally consistent. As shown in Table 6, the reliability values of OC and CP were 0.905 and 0.934, respectively, which indicated the items perform very well in terms of OC and CP reliability. For formative scales, the reliability values of WC and PI were 0.458 and 0.723, respectively. But as stated above, high reliability values are not expected for formative scales.

**Table 6 KSBS internal consistency reliability and intercorrelations with new data**

| | *1* | *2* | *3* | *4* |
|---|---|---|---|---|
| 1. Written contributions (WC) | (0.458) | 0.176* | 0.177* | 0.287** |
| 2. Organizational communications (OC) | | (0.905) | 0.547** | 0.332** |
| 3. Personal interactions (PI) | | | (0.723) | 0.419** |
| 4. Communities of practice (CP) | | | | (0.934) |

*Note*: $N=196$, coefficient alpha on the diagonal, *$P<0.01$, **$P<0.0001$, one-tailed.

### Factor structure (scale dimensionality)

As was done in the previous pilot study, CFA was used to validate traditional reflective indicator models with new data collected. For reflective indicator models of OC and CP subscales, CFA was conducted the same as that for study 3. All fit indices values of the OC and CP model were over or close to 0.90 that indicated good model fit. And the RMSEA and RMR values were 0.100 and 0.054, respectively, which also indicated an adequate fit.

However, for complicated formative indicator models, the causal indicator model in isolation is statistically underidentified. In this study, for formative model testing, the Multiple Indicators Multiple Causes (MIMIC) model method was used (MacCallum & Browne, 1993; Jarvis *et al*., 2003), which is a particular case of the general SEM. The MIMIC model, as shown in Figure 3, refers to a single latent variable with MIMIC (observed $x$ variables and $y$ variables).

From the SEM point of view, the left equation in Figure 3 can be regarded as a structural model, while the right equation can be regarded as a measurement model (Hatcher, 1994). In this study, two MIMIC models were established for WC and PI factors of KSBS. Both models are a single construct with several formative and several reflective measures. MIMIC-WC model has five formative indicators and two reflective indicators, while MIMIC-PI has eight formative indicators and two reflective indicators. In Figure 3, all $X$ are measures of the key construct, like the five formative indicators of WC factor. $Y_1$ and $Y_2$, to be reflective in nature, need to be content-valid measures tapping the overall level of the construct. Examples of potentially appropriate reflective items could be 'Overall, I frequently share my knowledge through written communications,' etc. Therefore, with the addition of these two reflective indicators, the WC and PI constructs would have two paths emanating from it and be identified.

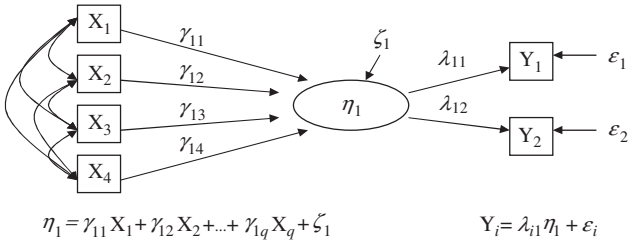


**Figure 3** Path diagram for MIMIC model.

For formative indicator models of WC and PI subscales testing, SEM was conducted with the 196 new data to determine the fit of the MIMIC model to the data. First, the same as in the examination of reflective factor structure, reviews of chi-square test, fit indices, and factor loading test are required to examine the model fit. The SEM results, as shown in Table 7, indicated that both WC and PI models now have a better fit of the data than the previous CFA model results. All CFI, NFI, NNFI, and GFI values over 0.90 indicate an acceptable fit. And RMSEA and RMR values of 0.10 or less indicate an acceptable fit. All these values showed adequate model fits. The PI model results especially indicated a very good model fit.

### Validity assessment

Although reliability assures that a scale can consistently measure something, it does not assure that it will measure what it is designed to measure. The property of measuring what a scale intends to measure is validity. There are several types of validity such as content validity (adequacy), construct validity (accuracy), and criterion-related validity (prediction).

In the previous sections, face and content validity have been discussed and examined. Criterion-related validity, also called statistical validity or empirical validity, refers to the extent to which a scale performs as expected in relation to some external variables (or criteria). Since examining criterion-related validity requires more time and effort than is proposed in this study, criterion-related validity was not explored in this study.

In the following section, we focused on the examination of construct validity (convergent and discriminant validity), which is the essential property for a scale. It refers to the extent to which a measure can be said to accurately measure the theoretical construct. We can understand it as the correlation coefficient between the construct and the measure, though it is not real operationally. To establish the construct validity of a measure, we need to determine the extent to which the measure correlates with other measures designed to measure the same thing (convergent validity) and the extent to which the measure differs from other measures designed to measure different things (discriminant validity). Neither is easy to achieve.

#### *Convergent validity*

Convergent validity refers to the extent to which the measure correlates with other measures that were

**Table 7 MIMIC models testing**

| | *Chi-square* | *d.f.* | *P* | *RMSEA* | *CFI* | *NFI* | *NNFI* | *GFI* | *RMR* |
|---|---|---|---|---|---|---|---|---|---|
| WC model | 3.49 | 3 | 0.3209 | 0.029 | 0.995 | 0.971 | 0.965 | 0.994 | 0.018 |
| PI model | 17.82 | 6 | 0.0067 | 0.100 | 0.977 | 0.968 | 0.829 | 0.982 | 0.025 |

*Note*: $N = 196$.

designed to measure the same thing. A measure with convergent validity should correlate highly with other measures to measure the same construct (Spector, 1992). The measures used to compare could be either different scales or different methods (e.g., observation, interview). Since the KSBS designed in this study is the first scale that tried to measure the construct of KSB reliably and validly, there is no other available valid scale or method to compare in order to calculate convergent validity of the KSBS.

One mathematical way to examine convergent validity (only for reflective models) is through the loadings of specific items. Anderson & Gerbing (1988) suggested that convergent validity can be indicated when each of the item's loadings on the construct is greater than twice its standard error. Factor loading coefficients of OC and CP factors, as shown in Table 8, were all greater than twice their standard errors, which suggest that OC and CP subscales have convergent validity.

In addition, if a factor loading of a reflective scale is below 0.707, there is more error or unique variance associated with that item than common variance. In this case, AVE is conducted, which is an index to assess the amount of variance that is captured by an underlying factor in relation to the amount of variance due to measurement error. As calculated and presented in Table 9, both AVE values for OC and CP exceeded 0.50 (0.553 and 0.678, respectively), which means more than 50% of the variance is captured by the factors, and therefore OC and CP subscales have convergent validity.

**Table 8 Factor loading tests with new data**

| *Item* | *Factor loading* | *Designated factor* | *SE* | *t Value* |
|---|---|---|---|---|
| 1 | 0.090 | WC | 0.066 | 1.35 |
| 2 | 0.214 | WC | 0.089 | 2.40 |
| 3 | 0.289 | WC | 0.112 | 2.58 |
| 4 | 0.933 | WC | 0.209 | 4.45 |
| 5 | 0.405 | WC | 0.112 | 3.59 |
| 6 | 0.625 | OC | 0.050 | 12.50 |
| 7 | 0.721 | OC | 0.057 | 12.65 |
| 8 | 0.660 | OC | 0.044 | 15.01 |
| 9 | 0.564 | OC | 0.049 | 11.52 |
| 10 | 0.585 | OC | 0.047 | 12.45 |
| 11 | 0.645 | OC | 0.058 | 11.07 |
| 12 | 0.565 | OC | 0.056 | 9.93 |
| 13 | 0.571 | OC | 0.059 | 9.64 |
| 14 | 0.260 | PI | 0.059 | 4.39 |
| 15 | 0.395 | PI | 0.073 | 5.41 |
| 16 | 0.457 | PI | 0.049 | 9.17 |
| 17 | 0.461 | PI | 0.053 | 8.68 |
| 18 | 0.601 | PI | 0.051 | 11.77 |
| 19 | 0.571 | PI | 0.043 | 13.23 |
| 20 | 0.182 | PI | 0.097 | 1.86 |
| 21 | 0.328 | PI | 0.062 | 5.26 |
| 22 | 0.886 | CP | 0.054 | 16.21 |
| 23 | 0.860 | CP | 0.049 | 17.31 |
| 24 | 0.857 | CP | 0.048 | 17.85 |
| 25 | 0.852 | CP | 0.053 | 16.01 |
| 26 | 0.723 | CP | 0.063 | 11.45 |
| 27 | 0.751 | CP | 0.067 | 11.14 |
| 28 | 0.590 | CP | 0.065 | 9.01 |

Another method that can be used to estimate subscales' convergent validity in some way is to compare overall rating scores of KSB subscales with relative overall rating question results got through the survey. The Pearson correlation coefficients' results were shown in Tables 10–13. For OC and CP subscales, all correlation values indicated moderate correlations (0.4–0.7) with $P<0.0001$. For WC and PI subscales, only weak positive relationships were found. All these results are reasonable: the homogeneity of reflective items determines that an overall rating of a scale should be correlated with all items of the scale; the heterogeneity of formative items determines that an overall rating of a scale makes it hard to reflect the different contributions of each item to the scale.

### *Discriminant validity*

Discriminant validity refers to the extent to which the measure differs from other similar measures designed to measure different things. It shows that the new measure is indeed novel, and not just a reflection of other variables. Discriminant validity of the KSBS was assessed in terms of the correlation between the KSBS and the scale of OCB (Organ, 1988), and the correlations between the different dimensions of the KSBS. Our hypotheses are that KSB and OCB are expected to be different constructs (refer to the section 'A definition of KSB'), and that the different dimensions of KSB represent different facets of the scale. Discriminant validity can be indicated by relatively low correlations. OCB measurement items were adopted from Smith *et al*. (1983).

Results of the last column in Table 14 showed that the correlations between the KSBS and the OCB scale, and among the four KSB subscales and the OCB scale are all relatively low or non-significant. All values were below 0.37. In addition, the correlations between different KSB subscales or dimensions were also only moderate or low (0.17–0.55). These results indicated that the KSB and OCB are different constructs and that the different dimensions of KSB represented different facets of the scale, and therefore discriminant validity of the KSBS was demonstrated.

Furthermore, mathematically discriminant validity can be examined through the evaluation of the AVE (Fornell & Larcker, 1981). They suggested that the AVE for each construct should be greater than the squared correlation between that construct and any other. Otherwise, the variance accounted for by a construct explains less variance than that explained by that construct's correlation with another, thus indicating a lack of discriminant validity. As shown in Table 15, the AVE values were those on the diagonal. They can be compared to the other three correlation numbers either in the same row or in the same column. All AVE values were larger than the squared

**Table 9 Standardized factor loading and average variance extracted values**

| *Item* | *Standardized factor loading* | *Designated factor* | *Indicator reliability* | *Error variance* | *Average variance extracted* |
|---|---|---|---|---|---|
| 1 | 0.114 | WC | 0.012 | 0.987 | WC: 0.202 |
| 2 | 0.216 | WC | 0.046 | 0.953 | |
| 3 | 0.235 | WC | 0.055 | 0.944 | |
| 4 | 0.858 | WC | 0.736 | 0.263 | |
| 5 | 0.399 | WC | 0.159 | 0.840 | |
| 6 | 0.773 | OC | 0.597 | 0.402 | OC: 0.553 |
| 7 | 0.779 | OC | 0.606 | 0.393 | |
| 8 | 0.871 | OC | 0.758 | 0.241 | |
| 9 | 0.730 | OC | 0.532 | 0.467 | |
| 10 | 0.771 | OC | 0.594 | 0.405 | |
| 11 | 0.709 | OC | 0.502 | 0.497 | |
| 12 | 0.653 | OC | 0.426 | 0.573 | |
| 13 | 0.638 | OC | 0.407 | 0.592 | |
| 14 | 0.331 | PI | 0.109 | 0.890 | PI: 0.314 |
| 15 | 0.402 | PI | 0.161 | 0.838 | |
| 16 | 0.634 | PI | 0.401 | 0.598 | |
| 17 | 0.607 | PI | 0.368 | 0.631 | |
| 18 | 0.770 | PI | 0.592 | 0.407 | |
| 19 | 0.840 | PI | 0.705 | 0.294 | |
| 20 | 0.144 | PI | 0.020 | 0.979 | |
| 21 | 0.392 | PI | 0.153 | 0.846 | |
| 22 | 0.901 | CP | 0.811 | 0.188 | CP: 0.678 |
| 23 | 0.935 | CP | 0.874 | 0.125 | |
| 24 | 0.951 | CP | 0.904 | 0.095 | |
| 25 | 0.894 | CP | 0.799 | 0.200 | |
| 26 | 0.716 | CP | 0.512 | 0.487 | |
| 27 | 0.701 | CP | 0.491 | 0.508 | |
| 28 | 0.594 | CP | 0.352 | 0.647 | |

*Note*: $N = 196$.

**Table 10 Pearson correlation coefficients for WC factor**

| | *1* | *2* | *3* |
|---|---|---|---|
| 1. Written contributions (WC) | | 0.180* | 0.179* |
| 2. Overall WC frequency | | | 0.465** |
| 3. If WC is a usual way agreement | | | |

*Note*: $N = 196$, *$P < 0.01$, **$P < 0.0001$, one-tailed.

**Table 11 Pearson correlation coefficients for OC factor**

| | *1* | *2* | *3* |
|---|---|---|---|
| 1. Organizational communications (OC) | | 0.407** | 0.429** |
| 2. Overall OC frequency | | | 0.479** |
| 3. If OC is a usual way agreement | | | |

*Note*: $N = 196$, *$P < 0.01$, **$P < 0.0001$, one-tailed.

**Table 12 Pearson correlation coefficients for PI factor**

| | *1* | *2* | *3* |
|---|---|---|---|
| 1. Personal interactions (PI) | | 0.437** | 0.230* |
| 2. Overall PI frequency | | | 0.218* |
| 3. If PI is a usual way agreement | | | |

*Note*: $N = 196$, *$P < 0.01$, **$P < 0.0001$, one-tailed.

**Table 13 Pearson correlation coefficients for CP factor**

| | *1* | *2* | *3* |
|---|---|---|---|
| 1. Communities of practice (CP) | | 0.537** | 0.665** |
| 2. Overall CP frequency | | | 0.545** |
| 3. If CP is a usual way agreement | | | |

*Note*: $N = 196$, *$P < 0.01$, **$P < 0.0001$, one-tailed.

correlations between the factor and the other three factors, which demonstrated discriminant validity of the KSBS.

### *External validity*

Furthermore, a simple test relevant to external validity, as Diamantopoulos & Winklhofer (2001) suggested, was conducted for formative subscales WC and PI. This external validity test is a necessary step for formative construct development. As discussed previously, we need to be cautious when removing an item of a formative scale because omitting an item is omitting a part of the construct. However, 'an excessive number of indicators is undesirable because of both the data collection demands

**Table 14 Discriminant validity tests**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Knowledge sharing behavior (KSB) | | | | | | 0.364** |
| 2. Written contributions (WC) | | | 0.176* | 0.177* | 0.287** | 0.021 |
| 3. Organizational communications (OC) | | | | 0.547** | 0.332** | 0.338** |
| 4. Personal interactions (PI) | | | | | 0.419** | 0.394** |
| 5. Communities of practice (CP) | | | | | | 0.224* |
| 6. Organizational citizenship behavior (OCB) | | | | | | |

*Note*: $N = 196$, *$P < 0.01$, **$P < 0.0001$, one-tailed.

**Table 15 Average variance extracted and squared correlation values**

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Written contributions (WC) | (0.202) | 0.030 | 0.031 | 0.082 |
| 2. Organizational communications (OC) | 0.030 | (0.553) | 0.299 | 0.110 |
| 3. Personal interactions (PI) | 0.031 | 0.299 | (0.314) | 0.175 |
| 4. Communities of practice (CP) | 0.082 | 0.110 | 0.175 | (0.678) |

*Note*: $N = 196$, AVE on the diagonal.

**Table 16 Pearson correlation coefficients for WC items**

| WC | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| KSBS | 0.287* | 0.326** | 0.242* | 0.369** | 0.265* |

*Note*: $N = 196$, *$P < 0.01$, **$P < 0.0001$, one-tailed.

**Table 17 Pearson correlation coefficients for PI items**

| PI | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|
| KSBS | 0.440** | 0.464** | 0.364** | 0.449** | 0.439** | 0.474** | 0.495** | 0.569** |

*Note*: $N = 196$, *$P < 0.01$, **$P < 0.0001$, one-tailed.

it imposes and the increase in the number of parameters when the construct is embedded within a broader structural model' (Diamantopoulos & Winklhofer, 2001, p. 272).

To improve the quality of the formative scales, Diamantopoulos and Winklhofer suggested a simple way of correlating each item to another external variable and eliminating those items with non-significant correlations. A global item summarizing the essence of the construct (like KSBS) can be used as a good external variable. The Pearson correlation coefficients' results were shown in Tables 16 and 17. All correlation values indicated that each item significantly correlated with the KSBS at $P < 0.01$. Therefore, all formative items should be retained for the KSBS.

## Conclusions and discussion

The primary purpose of this study is to develop and validate a new scale of KSBs with desirable psychometric properties. Overall, this study contributes to the existing research on KSB measures by identifying the construct of KSB, proposing a new taxonomy to categorize different behaviors into four dimensions of KSB, developing items for each of the four categories, and empirically testing its validity and reliability. The new KSBS was a 4-dimensional, 28-item, 5-response choice frequency scale. The results provided evidence of the dimensionality, reliability, and validity of the scale.

This study has some limitations. First, there are some weaknesses of the sampling methods used in this study due to difficulties of large survey data collection. For the pilot study, the KSBS was pre-tested using a convenience sample of 212 subjects. Because there was a lack of randomization for the convenience sample, we cannot be very sure about the characteristics of the sample pool. There might be some unobserved variables that may influence the results. For the validation study, the sample is limited to only one large company of one particular industry – high technology.

Thus, the findings and implications drawn from this study might not be readily generalized to other industries. However, the results of the pilot study and the validation study were very similar which strongly argues for the reliability and validity of the KSBS.

The second limitation is related to formative scale validation, including model identification, scale dimensionality, reliability, and validity examination difficulties. Up until now, there was no standard method to assess reliability of formative scales. In this study the author tried the MIMIC model to test the scale dimensionality to some degree.

The third limitation is that the typical approach to examine convergent validity was not used in this study. Currently there is no other available valid scale or method to compare in order to calculate convergent validity of the KSBS. In this study, I tried to test the convergent validity of traditional reflective scales to some degree through a mathematical method and correlations with overall rating items.

To the extent this study was limited more extensive studies might overcome the limitations of the present study. Furthermore, this study suggests several possibilities for future research, like investigating on criterion validity examination, and more correlation studies with the scale established.

The initial validation process in this study provided support for a promising new measure of KSB. The next step could be to examine criterion-related validity that indicates that a scale performs as expected in relation to some external variables. As stated previously, it focuses on specific relationships that were theoretically justified in the literature review. For example, the relationships between KSB and other variables (e.g., rewards, trust, or commitment) may be hypothesized and tested to see if criterion-related validity can be established for the KSBS.

Another research possibility is to use the reliable and valid KSBS developed in this study as an instrument in hypothesized relationships research related to KSB in the future field studies conducted by researchers. It is, in fact, the major theoretical contribution and one of the ultimate goals of this study.

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## Appendix

### Knowledge sharing behavior scale items

*Written contributions*

1. Submit documents and reports.
2. Publish papers in company journals, magazines, or newsletters.
3. Share documentation from personal files related to current work.
4. Contribute ideas and thoughts to company online databases.
5. Keep others updated with important organizational information through online discussion boards.

*Organizational communications*

1. Express ideas and thoughts in organizational meetings.
2. Participate fully in brainstorming sessions.
3. Propose problem-solving suggestions in team meetings.
4. Answer questions of others in team meetings.
5. Ask good questions that can elicit others' thinking and discussion in team meetings.
6. Share success stories that may benefit the company in organizational meetings.
7. Reveal past personal work-related failures or mistakes in organizational meetings to help others avoid repeating these.
8. Make presentations in organizational meetings.

*Personal interactions*

1. Support less-experienced colleagues with time from personal schedule.
2. Engage in long-term coaching relationships with junior employees.
3. Spend time in personal conversation (e.g., discussion in hallway, over lunch, through telephone) with others to help them with their work-related problems.
4. Keep others updated with important organizational information through personal conversation.
5. Share passion and excitement on some specific subjects with others through personal conversation.
6. Share experiences that may help others avoid risks and trouble through personal conversation.
7. Have online chats with others to help them with their work-related problems.
8. Spend time in e-mail communication with others to help them with their work-related problems.

*Communities of practice*

1. Meet with community* members to create innovative solutions for problems that occur in work.
   *Community: an informal network of people within or across organizations who voluntarily share common practice, expertise, and interests on specific topics. It is neither an organizational unit nor a team.
2. Meet with community members to share own experience and practice on specific topics with common interests.
3. Meet with community members to share success and failure stories on specific topics with common interests.
4. Meet with community members to work to encourage excellence in community's practice.
5. Support personal development of new community members.
6. Send related information to members through community e-mail list.
7. Share ideas and thoughts on specific topics through company supported online community-of-practice system.
   *The five-point frequency responses are: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always.

## About the author

**Jialin Yi**, Ph.D. Senior E-learning Instructional Designer. She got her doctoral degree from the Instructional Systems Technology department at Indiana University Bloomington, where she also taught computer skills courses for 3 years. Her research interests are knowledge management, performance evaluation and improvement, training techniques, instructional design, and distance learning. Jialin earned a master of science in Instructional Technology from Indiana University Bloomington, a master of management in Industrial Engineering and a bachelor of engineering in International Trade from Xi'an Jiaotong University in China. She also worked in Agilent Technologies as an E-Learning Specialist for 15 months. She has been working in Northwestern Memorial Hospital as a Senior E-Learning Instructional Designer since March 2007. She had academic and practical experience in areas of economics, management, industrial engineering, and education.