Examining Voluntary Engagement Barriers in Knowledge Sharing Practices for Supply Chain Innovation

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ABSTRACT

Voluntary engagement (VE) creates a sense of coordination and harmonization to share knowledge. The eminence of knowledge sharing (KS) for supply chain (SC) innovation is undeniable to initiate development in products, services, and operations. However, KS process is undergoing challenges in sustaining KS engagement by SC partners. Hence, recent researchers call for the need to address this gap in the literature to assess VE barriers. This paper studies the causal relationship of VE barriers on two MNCs (i.e., Toyota and Suzuki) via the fuzzy DEMATEL approach. The case examination findings indicate culture’s alignment as the prime cause of VE, and leadership commitment has stronger interdependence. The core problems which need elimination are fear of losing the job, prominence, and opportunistic behavior. The study concludes that companies need to instigate the natural attributes of employees’ VE by setting up earnest guidelines to practice free information and knowledge flow.

KEYWORDS
Knowledge Sharing (KS), Organizational Climate, Organizational Culture, Supply Chain Innovation, Trust, Voluntary Engagement (VE)

1. INTRODUCTION

In a highly competitive business environment, organizations are steadily focusing on knowledge sharing (KS) among supply chain (SC) allies (e.g., employees, suppliers, retailers and customers) aiming to excel SC performance to furnish better yields and greater customer satisfaction. KS serves as the fundamental source for organizations where employees participate in knowledge application and innovation (Seetharaman et al., 2019). Several companies have successfully implemented knowledge management practices like Ford, General Electric and Amazon to cater to the needs of different organizational facets. The inter and intra-organizational KS supports SC partners to boost competitive
advantage by sharing experiences, frequent operations and innovation practices to resolve strategic and operational issues (An-Shuen Nir, 2012; Cheng et al., 2008; Wang et al., 2008).

The KS process is dependent on the partner’s cooperation and relationships with each other, which closely links with engagement practices. In a corporate environment, engagement refers to employees’ emotional connection with job role in organization. However, an encouraging form of engagement practices is voluntary engagement (VE). VE is promising psychological disposition of a volunteer (e.g. employee, partner) that shows itself in cognitive, mental, physical, social and spiritual contributions that occur through collaborative interactions (Conduit et al., 2019). VE can play a crucial role in KS for SC innovation because it can unite SC partners and staff emotionally with the organization, job role and organizational goals (Osterloh & Frey, 2000). Employees with high VE would show high dedication to the company. Subsequently, VE encourages partners to share insights into different work scenarios, innovation practices (Osterloh & Frey, 2000) and better dynamic methods of KS (Teng & Song, 2011).

In the era of fierce competition, many firms leverage cost and performance benefits to enhance SC partners’ engagement (employees, suppliers, distributors, etc.). In the automotive sector, automobile manufacturers’ performance and success heavily depend on their upstream and downstream partners. Therefore, the depth and smooth flow of sharing knowledge and information across SC allow the manufacturer to stay innovative and successful in the marketplace. Nevertheless, KS process is undergoing challenges as it has many barriers in sustaining VE by SC partners. KS is a major challenge faced in the business partner network (Vuori et al., 2019) as SC partners are unwilling to share knowledge voluntarily. Razmerita et al. (2016) supported this statement by highlighting that KS is not an actual uncertainty for organizations and it can be achieved through how knowledge workers perceive its significance. The obstacles that a firm may face during the KS process does not affect directly but slow down the entire learning process. Consequently, an organization is on a stake of losing its innovation capabilities. Thus, the need to examine VE of SC partners is very crucial for organizations to attain unrestricted flow of knowledge across SC. In addition, the alternative idea of offering monetary rewards has some insignifact findings from past studies. According to Lin (2007), the perceived organizational reward does not significantly impact employee attitude and intention of sharing knowledge. A few more studies showed somewhat similar findings that tacit knowledge, i.e. the knowledge gained from personal experience has an insignificant relation with organizational reward (Hau et al., 2013; Martín et al., 2009). Duckworth (2016) provided evidence that the majority of employees were not engaged in the workplace due to working conditions and the environment. Smith et al. (2016) further enhanced the work on the subject and reported the need for employee commitment and culture of high engagement. Moreover, in 2017 Deloitte surveyed volunteerism revealed that employees (millennials) who regularly involved in volunteer conduct at the workplace feel more honoured, loyal and satisfied. Contrary to those involved not often or not ever, study further suggests a linkage between VE and perceived workplace culture. All these barriers towards KS practices could jeopardize knowledge transfers among SC partners which could then lead to a serious impact on innovation. As such, VE barriers in KS practices need to be urgently addressed to sustain SC innovation.

Past researchers had studied various factors that inhibit KS practices; however, vis-à-vis the study of VE inhibiting KS factors in SC innovation has yet to be explored. As echoed by Rajabion et al. (2019), VE should be further studied in details because this encouraging form of engagement is the foundation of innovation and competitive advantage. By understanding interrelationship among VE barriers, KS practices can be further enhanced and nurtured to achieve SC innovation. Therefore, this study will examine the barriers of VE, which could jeopardize consistent sharing of experience and innovative practices among staff and SC partners. We will use the fuzzy DEMATEL approach to determine the causal relationship among the factors. This study’s distinctive contribution is to untap the imperative role of VE for KS in organizations. The concept of VE has mainly studied for public issues, sports and welfare activities. The present study intends to classify the inhibitors of VE
in companies, which had never been identified before. Moreover, this study also developed separate categorizations for the inhibitors concerning their influence on KS by using the fuzzy DEMATEL approach. These categorizations will facilitate decision-makers to take appropriate strategies and actions for sustaining SC innovation.

The rest of the paper is organized as follows. In Section 2, a literature review is presented. The review covers existing studies on KS barriers, SC innovation and VE in KS context. Section 3 discussed the methodology, i.e., the Fuzzy DEMATEL approach. Results and findings discussion are presented in Section 4. In Section 5, the managerial implications of the causal relationship of VE barriers pertaining to KS are presented. The concluding remarks which cover the limitations and future work are presented in Section 6.

2. LITERATURE REVIEW

2.1 Existing Studies on Knowledge Sharing (KS) Barriers

Knowledge management refers to the ways companies successfully store, retrieve, manage and improve their intellectual assets. For companies, sharing knowledge is crucial to utilizing employees’ abilities and willingness to share within groups and social networks, towards organizational learning capability and innovation.

Paroutis and Al Saleh (2009) performed qualitative study followed by interviews of IT professionals and document review in a multi-national firm to discourse barriers to employees’ willingness to use and/or contribute their knowledge to web 2.0 platforms. Subsequently, Kumaresan and Swroopranji (2013), Nazim and Mukherjee (2013), Khan and Ali (2019) discussed attribute, attitude and perceptions hindering KS among librarians. Similarly in KS partnerships, the role of learning partner (organization) is very important to gain shared benefits vis-à-vis taking adequate measures to solve hindrance, enhance monitoring and performance evaluation. The dilemma of collective action between learning partners happened from conflicting interests, contextual, organizational and interpersonal factors among individuals and/or organizations that depress shared action (Buffardi et al., 2019).

Besides individual factors of willingness, leadership commitment and organizational factors were concerns of researchers. Culture is termed as a significant cause in the flow of knowledge (Long & Fahey, 2000). Reinforced by McDermott and O’Dell (2001), alignment of culture, core values, understanding existing culture, incorporation in business strategy, organization style, reward and recognition, the role of leadership and utilizing existing setup support KS. Further, Hendriks (2009) suggested a systematic procedure and performed a case study to offer rational findings by measuring and evaluating organizational culture. Rivera-Vazquez et al. (2009) examined organizational environment, manager commitment, localization of experts and emotional intelligence as part of organizational culture towards innovation and KS. Study on culture as a barrier to KS is further enhanced by incorporating national culture (Kivrak et al., 2014), cultural boundaries (Dulaimi, 2007) and online community of practice (Ardichvili et al., 2006; Li et al., 2007). On the contrary, Hall and Goody (2007) argue that power relations in terms of organizational politics will result in success or failure to foster KS.

Apart from above discussion, the literature on KS barriers has been reviewed systematically. A total of 142 papers has discussed KS barriers from diverse outlooks. The review confirms that no such work is done on ‘VE barrier for KS’, indicating there is still a gap in the literature. One reason for lack of studies on VE barriers in KS practices could be KS domain is more diversified because it is necessary for every business, facets, products and services. According to Razmerita et al. (2016) “KS is not a real ‘social dilemma’, but knowledge workers see the importance of KS and the altruistic behaviour.” VE is a behaviour of being active and interested in sharing knowledge voluntarily. Irrefutably, VE will encourage KS while lacking of it will jeopardize KS. The case examination has
been aimed at collectivism because it relies on interconnectedness. Hence this study will focus on 
VE as a barrier for KS in two Japanese-based (collectivism) MNCs.

2.2 Supply Chain (SC) Innovation

Innovation refers to the application of a new or improved product, process, marketing and 
organizational procedure, workplace arrangements and relations (Wagner, 2008). The innovation 
procedure takes in present knowledge. However, it frequently needs generating and obtaining new 
knowledge (Howells & Roberts, 2000). SC innovation is extensively acknowledged as significant for 
an organization’s growth. Craighead, Hult and Ketchen (2009) had observed in SCs that knowledge, 
innovation strategy and actions are antecedents of firm performance. The need to equate innovation 
cost and knowledge is the basic to attain better firm performance. The level of innovation in the SC 
allows a firm to stay resilient during uncertainties, and it is also the determinant of a firm’s ability 
to show robustness (Kwak et al., 2018). The SC innovation is categorized as the product, process, 
technological, organizational, marketing and resource allocation innovation (Gao et al., 2017).

Shete et al. (2020) revealed that SC partners’ collaboration and engagement is the most crucial 
enabler in achieving SC innovation for manufacturing industries. KS enables the SC to achieve 
continuous innovation by collaborating with SC partners to attain efficient and effective inventory 
forecast, production planning, strategic management, superior customer relations, cost and service 
delivery and enhanced upstream and downstream communication (Soosay et al., 2008). Singhry 
and Rahman (2019) found that SC innovation capability mediates the association between CPFR 
collaborative planning, forecasting, and replenishment and SC firm performance. Various other 
studies determine the extended benefits of KS for SCs. For example, Wu and Li (2020) empirically 
confirmed the significant impact of knowledge transfer on green SC innovation performance. Shamout 
(2020) also concludes the full mediation role of SC innovation towards robustness capability grounded 
by the knowledge-based view.

2.3 Voluntary Engagement (VE)

The global economy has turned into a knowledge economy where the entity with more information 
and knowledge would act more precisely to gain productivity and profitability by integrating suppliers, 
intermediaries and customers. Therefore, KS becomes a survival tool for entities to respond to highly 
dynamic markets (e.g., customer perception for product and quality, technology, environmental factor).

VE involve participants to attain particular goals. Teng and Song (2011) differentiated KS behaviour 
as solicited and voluntary; the sense of coordination and synchronization among the team considerably 
associated with voluntary sharing behaviour. It benefits tremendously towards the attainment of 
set targets. Engagement refers to the disposition of employees’ voluntary appearance developed by 
their analysis of workplace conditions (Shuck & Herd, 2012). Furthermore, employees and partners’ 
voluntary behaviour is derived from individual perception regarding how the firm treats him or her, 
repute of firm and employment practices. From past studies the concept of voluntary or volunteer is 
primarily used in social context. To the best of our understanding, the connotation of VE with KS 
has not been studied by any researchers in manufacturing concerns.

To identify the VE barriers, Rajabion et al. (2019) draw attention to corporate and industrial culture, 
work routines and restricted environment. According to SHRM (The Society for Human Resource 
Management), employee engagement is affected by organizational culture and communication, trust 
and respect from management, governance, and its perceived status.

Next, we will discuss three main criteria for VE, i.e. organization culture, organization climate 
and trust. Each criterion will then be further decomposed into its related aspects and explanation 
will be provided for each aspect.
2.4 Organizational Culture as an Inhibitor of Voluntary Engagement (VE)

Culture in organizations is a multi-layered paradigm, collection of shared attitudes, values, goals, procedures and beliefs that create cohesion within an organization (Lemken et al., 2000). Culture is an essential behavioural prospect that allows or restricts individuals to engage discretionary in the KS process. Culture outline norms to signify importance to any piece of knowledge, facilitate relationships, create social interaction opportunities, nurture KS and innovation practices (Long & Fahey, 2000). According to the American Productivity and Quality Centre (APQC), which is known for standardization, case studies and procedures for performance management, KS emphasizes the need for KS culture. Organizations should nurture a KS culture to allow staff to participate in sharing experiences and innovation so that KS can be perceived as a natural practice instead of an obligation. Culture is composed of two aspects of culture, i.e., alignment and leadership commitment.

Alignment of Culture (A1): Mcdermott and O’Dell (2001), along with Teng and Song (2011) revealed that organizational culture would slow down the KS process when it is not aligned to promote KS values. Therefore alignment of existing culture is the compulsion to flourish KS values for the success of every organization. How a firm position its values is reflected in the behavior of employees. For example, Toyota has set its value of sharing innovative ideas across the organization. They use the term “Yokoten” which refers to “best practices sharing” that promotes horizontal sharing of knowledge and ideas within company and affiliates. Sayyadi et al. (2018) appraised no participation as a prime cause of failure of knowledge management systems.

Lack of Leadership Commitment (A2): Aggregation of efforts, policies, protocols and mechanisms that nurture KS behavior portrays leadership commitment. Good leadership does not set rules and regulations but provide training to employees and establishes development programs that boost morale, confidence, awareness and sense of being valued. Chión et al. (2019) pointed out that leadership commitment and support marks the establishment of flexible structures that offers unrestricted knowledge and information flow across the organization. The top reason for knowledge acquisition, management and sharing failures is lack of leadership commitment (Sayyadi et al., 2018).

Hence, considering the barriers mentioned above of organizational culture, we can recognize that a better cultural atmosphere may lead to voluntary sharing of knowledge by sharing experiences and innovative practices to sustain innovative capabilities.

2.5 Organizational Climate as an Inhibitor of Voluntary Engagement (VE)

Climate is composed of seven aspects of culture, i.e., employee involvement and autonomy, manager’s treatment, inter-departmental integration and conflict, employee welfare, training and development, structure formalization, precision in strategy and vision and feedback on the quality of shared knowledge. Organizational climate is determined from the shared perception of culture by employees which are associated with judgements, feelings and behavior of employees (Denison, 1996). Forming an atmosphere of KS willingness is a challenging task for organizations (Chión et al., 2019). Patterson et al. (2005) has empirically and theoretically validated the dimensions of organizational climate for productivity and innovation by refining previous measures, human relations approach, internal process approach and rational goal using competing values model. Flamholtz and Randle (2014) further assured that corporate culture and climate are resilient inspirations for employees’ attitudes and behavior. The barriers pertain to organizational climate are as follows:

Lack of Employee Involvement and Autonomy (A3): The extent of employee involvement in putting KS into practice increases the likelihood of stakeholder participation (Levy et al., 2010). It boosts employee morale to participate in the information sharing process because of their perception of being valued by sharing organizational goals and plans (Riordan et al., 2005). Organizational structures can inhibit the KS process within stakeholders. In a study by Tsai (2002), he found that a strict hierarchical structure with centralized reporting has a negative impact on KS. In this scenario, the staff felt uncomfortable due to restricted independence and they supposed to get consent from the
reporting manager in all their decisions. Autonomy needs are directly associated with VE (Boezeman & Ellemers, 2009).

**Aggressive Treatment of Managers (A4):** Shuck et al. (2011) suggest that supervisor support is a critical antecedent of developing employee engagement. Aggressive treatment of managers on task feedback threatens workplace climate and shattered employees’ trust in self and motivation. Supervisors’ valuing and caring practices offer a healthy, productive and safe environment for employees.

**Lack of Inter-Departmental Integration and Conflicts (A5):** When employees in the organization have inter-departmental conflicts, lack of respect, and mistrustful relations, would create an inverse effect on the organization’s ability of integration to share knowledge and collaboration. According to Kahn and Mentzer (1996), integration consists of interaction and collaboration. Integration refers to communication (e.g., KS and meetings), and collaboration refers to inter-departmental willingness to do collective effort performing organizational tasks. Collaboration is a vital factor of perceived culture, resulting in effective KS. Instead of opting for new ways of improving organizational practices, organizations should adopt initiatives that enrich integration and healthy relationships in freely sharing knowledge (Chión et al., 2019). On the other hand, ineffective information integration would occur in the event of stakeholders’ dominant and weak behavior. Subsequently, the lack of integration would hinder process improvement and innovation.

**Lack of Employee Welfare, Training and Development (A6):** Sundaray (2011) emphasized employees’ health and safety because employees’ engagement with the organization would be distracted when employees feel insecure during at work. A high engagement level exerts commitment and involvement of employees towards organizational values. Moreover, corporate policies and practices about workers’ well-being considerably elevate workplace performance and KS (Bryson et al., 2015; Ford et al., 2015).

Training is a systematic procedure of learning to develop individuals or teams on a specific plan, whereas development is acquiring new skills and knowledge. The training and development programs elevate employees’ intrinsic motivation, which subsequently empowers employee performance, organizational citizenship behavior of helping and boost effectiveness on certain goals (Dysvik & Kuvaas, 2008). Vice versa, lack of training and development programs would lead to low intrinsic motivation which will then discourage improvement and threatens performance.

**Stressing on Strong Formalization (A7):** Emphasizing formalization in the internal process would disappoint partners to perceive the organization as a collaborative workplace. It inhibits employees’ upstream and downstream communication, which becomes a noticeable barrier for trustable conversations (Huang & Vliert, 2006). When it is less formalized and integrated, partners’ harmony and interaction will be more encouraging to share knowledge (Chen & Huang, 2007; Yeşil & Hırlak, 2019). Therefore, strong formalization disengages them from acting voluntarily to share work knowledge besides personal experiences.

**Lack of Precision in Strategy and Vision (A8):** Yeşil and Hırlak (2019) highlighted that lack of precise strategy and vision, along with other organizational factors, would result in the reduction of KS willingness of individuals. For example, the pressure to produce could harm the organisation’s rational goals. An employee’s increasing workload deviates them from sticking to their routine jobs; the time constraint confines them to use existing knowledge only. Moreover, a high burden of work and time pressure to produce results discourages KS because of lack of time to think and interact within teams (Huysman & de Wit, 2004; Seba et al., 2012).

**Lack of Feedback on The Quality of Shared Knowledge (A9):** According to expectancy-value theory, people tend to participate less when they feel shared information is not useful. Cabrera and Cabrera (2002) discussed that employee participation would be higher when they feel that shared knowledge or information has valued for co-workers and management and vice versa. Feedback about the quality and value of information, experiences and innovative practices would encourage an employee to stay engaged happily.
Therefore, for organizations to sustain VE, sensible inspection and evaluation of climate is a must and organization should encourage actions that strengthen vertical and horizontal relationships (Nencini et al., 2016) so that partners willingness of participation in KS helps in SC innovation.

2.6 Trust as an Inhibitor of Voluntary Engagement (VE)

Trust is a dynamic predecessor of KS that creates coherence in relations between co-workers, subordinate and managers, employees, employers and business partners. The trustworthy association leads to unobstructed KS, empowers collective knowledge, knowing what task others are doing and a sense of assertiveness that the whole team is contributing to the objectives of the organization (Ismail et al., 2007; Rosen et al., 2007). The association of trust with VE was empirically proved by Chen et al. (2012), who highlighted that trust influences employees’ voluntary performance.

We decomposed trust into three aspects, i.e., trust on peers, trust on management and competence-based and benevolence-based trust. The explanations are as follows.

Lack of Trust on Peers (A10): Trusting co-workers can be the outcome of individuals feeling that his or her peers will help in difficulty, facilitate when looked-for and how much to rely on their actions. On another note, knowledge misrepresentation or sharing restriction has severe implications for the SC, resulting in unnecessary inventories and operational inadequacies (Shih et al., 2012). The level of trust defines the intensity of voluntary commitment in KS practices in SCs hence, trust between co-workers has the power to moderate emotional commitment in KS process, and a low level of trust inhibits VE practices (Casimir et al., 2012; Jain et al., 2015).

Lack of Trust on Management (A11): Being trusted by the leader also positively affects an employee. Trustworthiness on leadership leads to organizational commitment. Similarly, trusting an immediate supervisor grows voluntary commitment with the organization (Kannan-Narasimhan & Lawrence, 2012). Alternatively, weak trust affects an employee’s helping behavior to share experience and information.

Competence (Fear of Losing Job and Prominence, and Benevolence Opportunistic Behavior) (A12): Trust as the power to eradicate the fear of losing job and repute from sharing knowledge one has related to job role and experiences. Rajabion et al. (2019) reported that employee resists sharing knowledge in a SC because having a fear of losing the job. This linked with competence-based trust. The sense of disagreement to save job and prominence inhibits voluntary participation as well as the flow of knowledge among peers and managers. In addition, possible rivalry and self-interest are consequences of opportunistic behavior, which damages the inter-organizational trust and KS in SCs (Cheng et al., 2008) and opposes collaboration and teamwork (Lui et al., 2009). This occurs when benevolence-based trust is low. The benevolence is linked to the theory of trust which determines that collective interest are significant in enlightening workplace relationships and inter-firm trust has no meaning without a sense of collective interest (Aurifeille & Medlin, 2009).

3. METHODOLOGY

This paper intends to recognize the notable barriers that restrict VE for KS to attain SC innovation. We have used fuzzy DEMATEL (decision-making trial and evaluation laboratory) approach to find a structural summary that represents a causal relationship of multifaceted organizational factors. In recent studies, many scholars used Fuzzy DEMATEL approach for innovative themes like blockchain technology (Yadav & Singh, 2020), service innovation (Feng & Ma, 2020), industry 4.0 (Sadeghi-Niaraki, 2020), socio-ecological performance (Solanki et al., 2020), behavioural factors in sustainable SC (Kumar et al., 2020), green SC (Wu et al., 2015) and etc.
3.1 Fuzzy Set Theory

Some significant definitions and notations of fuzzy set theory were reviewed from Chen (1996) and Cheng and Lin (2002). First consider $X$ to be the universe of discourse, $X = \{x_1, x_2, x_3, \ldots, x_n\}$. Then perform a fuzzy set of $A$ of $X$ shows a set of pairs $\{(x_1, fA(x_1)), (x_2, fA(x_2)), (x_n, fA(x_n))\}$. Here, the membership function of $A$ and $fA(x)$ represents as $fA : X \rightarrow [0, 1]$ also denotes a degree of membership of $x$ in $A$.

**Definition 1:** The fuzzy set $A$ is symbolised as $fA(x)$ for the finite or infinite set of $X$, where $x \in X$.

**Definition 2:** The fuzzy set $A$ is symbolised as $\sum ifA(x)$ for the finite or infinite set of $X$, where $x_i \in X$.

**Definition 3:** A fuzzy set $A$ of $X$ is said normal only if the membership function of $fA(x)$ satisfies maximum $fA(x)$ equals to 1.

**Definition 4:** A fuzzy number in the universe of discourse $X$ is a fuzzy subset which is not convex, but it can be normal as well.

**Definition 5:** The fuzzy $\alpha$-cut $A$ and strong $\alpha$-$\alpha$ of the universe of discourse $X$ of the fuzzy subset $A$ is symbolised as follows

$$A_\alpha = \{x | fA(x) \geq \alpha, x_i \in X\}, \text{ where } \alpha \in [0, 1]$$

$$A_\alpha^+ = \{x | fA(x) \geq \alpha, x_i \in X\}, \text{ where } \alpha \in [0, 1]$$

**Definition 6:** A fuzzy set $A$ of $X$ is convex on condition that every single $A_\alpha$ is convex. That means $A_\alpha$ is close to interval $P$, which can be represented as

$$A_\alpha = [P_1(\alpha), P_2(\alpha)], \text{ where } \alpha \in [0, 1]$$

**Definition 7:** A TFN (triangular fuzzy number) may also term as a triplet $(a_1, a_2, a_3)$. The Fuzzy number $A$ membership function is expressed as

$$fA(X) = \begin{cases} 0 & z < a_1 \\ \frac{(z-a_1)}{(a_2-a_1)} & a_1 \leq z \leq a_2 \\ \frac{(a_2-a_1)}{(a_3-a_2)} & a_2 \leq z \leq a_3 \\ 0 & z < a_3 \end{cases}$$

Consider $A$ and $B$ as triplet-parameterized TFNs $(a_1, a_2, a_3)$ and $(b_1, b_2, b_3)$ respectively. The operational laws of those two TFNs shall then be as follows:
\[ \tilde{A}(+) \tilde{B} = (a_1, a_2, a_3)(+) (b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \]
\[ \tilde{A}(-) \tilde{B} = (a_1, a_2, a_3)(-) (b_1, b_2, b_3) = (a_1 - b_1, a_2 - b_2, a_3 - b_3) \]
\[ \tilde{A}(\times) \tilde{B} = (a_1, a_2, a_3)(\times) (b_1, b_2, b_3) = (a_1 b_1, a_2 b_2, a_3 b_3) \]
\[ \tilde{A}(\div) \tilde{B} = (a_1, a_2, a_3)(\div) (b_1, b_2, b_3) = (a_1 / b_1, a_2 / b_2, a_3 / b_3) \]  

(4)

In equation 4, \( a_1, a_2 \) & \( a_3 \) are real numbers also \( a_1 \leq a_2 \leq a_3 \).

Decision making through group responses is vibrant to find the finest solution for the problem. Since the process involves census built on judgements of the number of individuals, thus acceptable judgment is expected to gain. To deal with the ambiguous nature of research, a fuzzy aggregation that comprises defuzzification method is needed that converts fuzzy numbers into the crisp score because the judgments of the human being with fuzzy linguistic variables are fuzzy numbers. The procedure developed by Opricovic and Tzeng (2004) is applied in this study, that objectively used to determine left and right scores through minimum and maximum fuzzy numbers. Conferring to membership function the aggregate score is defined as a weighted average.

Consider \( w^k_i = (a^k_{ij}, a^k_{ij}, a^k_{ij}) \), here in this equation, the \( i \) denotes degree of criterion that influences criterion \( j \) and \( k \) represents fuzzy questionnaires, i.e. \( (k = 1, 2, 3, \ldots, k) \).

Normalize the TFNs:

\[ xa^k_{ij} = (a^k_{ij} - \min a^k_{ij}) / \Delta_{\text{max}} \]
\[ xa^k_{2ij} = (a^k_{2ij} - \min a^k_{2ij}) / \Delta_{\text{max}} \]  
\[ xa^k_{3ij} = (a^k_{3ij} - \min a^k_{3ij}) / \Delta_{\text{max}} \]  

Where \( \Delta_{\text{max}} = \max r^n_{ij} - \min l^n_{ij} \)

Compute the left \( (\text{xls}^k_{ij}) \) and right \( (\text{xrs}^k_{ij}) \) normalized values:

\[ (\text{xls}^k_{ij}) = xa^k_{2ij} / (1 + xa^k_{2ij} - xa^k_{ij}) \]
\[ (\text{xrs}^k_{ij}) = xa^k_{3ij} / (1 + xa^k_{3ij} - xa^k_{2ij}) \]  

(6)

Obtaining the crisp values \( x^k_{ij} \):

\[ x^k_{ij} = [\text{xls}^k_{ij} (1 - \text{xls}^k_{ij}) + \text{xrs}^k_{ij} \times \text{xrs}^n_{ij}] / (1 - \text{xls}^k_{ij} + \text{xrs}^k_{ij}) \]  

(7)

Producing total normalized crisp values \( \tilde{\omega}^k_{ij} \):
\[ \omega^b_i = \min a^b_i + x^b_i \Delta_{\text{max}} \]  

(8)

Incorporate crisp values from different opinions of \( k \) respondents:

\[ \omega^k_j = \frac{1}{k}(\bar{w}^{b_1} + \bar{w}^{b_2} + \ldots + \bar{w}^{b_k}) \] 

(9)

3.2 The DEMATEL Approach

Gabus and Fontela, in the early 1970s, developed the DEMATEL technique to capture cause and effect relationships. The DEMATEL method has sufficient forte to deal with MCDM themes concerning causal associations between factors of a paradigm (Liu, 2016). It delivers reliable and authentic decision-making in situations where selecting the most favorable option is complicated. The DEMATEL approach is a structural modelling method based on graph theory; it presents a causal effect diagram determining interconnection and influential power of criterion with one another (Lin, 2013). In order to apply the DEMATEL method, it is prerequisite to consider system comprises of a set of criterion \( C = \{c_1, c_2, \ldots, c_n\} \), and pairwise relationship is derived from mathematical modelling. The steps of DEMATEL approach is as follows:

Step 1: Creating the Direct Relation Matrix

This step follows to create a direct relation matrix which requires comparison scale to assess relationships among criterion. The comparison scale comprises of four ranks 0, 1, 2, 3, 4 that denotes; no influence, very low influence, influence, high influence, very high influence respectively. The initial direct relationship matrix \( B \) is considered as \( n \times n \) matrix calculated from the pairwise comparison. Here, \( P_{ij} \) is referred to as how much influence criterion \( i \) impose on \( j \). This leads to form \( P = [p_{ij}]_{n \times n} \)

Step 2: Obtaining the Normalize Direct Relation Matrix

Using the direct relation matrix \( P \) to form the normalize relation matrix \( Q \) is obtained from below equation:

\[ Q = k \times B \] 

(10)

\[ k = \frac{1}{\max_{i \leq j \leq n} \sum_{j=1}^{n} p_{ij}}, \quad i, j = 1, 2, \ldots, n \] 

(11)

Step 3: Compute the Total Relation Matrix

When the normalized direct relation matrix \( Q \) is computed from equation (10), the following equation is applied to get the total relation matrix \( T \), where \( I \) is referred to the identity matrix.
\[ T = Q(I - Q)^{-1} \]  \hspace{1cm} (12)

Step 4: Constructing a Causal Effect Diagram

Apply the equations (5)-(7), the sum of rows and columns are inferred as vectors D and R, correspondingly within the total relation matrix T. The significance of each criterion “Prominence” is computed by adding D to R in the horizontal axis (D+R), likewise by subtracting D from R gives vertical axis (D-R) termed “Relation”, the (D-R) value regulates each criterion into cause and effect group, i.e. the criterion with negative (D-R) value plot into effect, alternatively for cause group. A cause and effect diagram for decision making can be plotted using (D+R) and (D-R) value of the criteria, can also be seen in Figure 2.

\[ T = \left[ t_{ij} \right]_{n \times n}, \quad i, j = 1, 2, \ldots, n \]  \hspace{1cm} (13)

\[ D = \left[ \sum_{i=1}^{n} T_{ij} \right]_{n \times 1} = \left[ T_i \right]_{1 \times 1} \]  \hspace{1cm} (14)

\[ R = \left[ \sum_{j=1}^{n} T_{ij} \right]_{1 \times n} = \left[ T_j \right]_{1 \times n} \]  \hspace{1cm} (15)

Step 5: Getting the Inner Dependence Matrix

The internal dependence matrix could be collected by means of the normalization method after summarizing each column in the total relation matrix, and the outcome of every column equals 1.

3.3 The Application Method of Fuzzy DEMATEL

The steps to solve the MCDM theme using fuzzy DEMATEL approach is as follows:

Step 1: Collecting the Related Information

The related information is attained from respondents of management roles in SC function. It is essential to get valid responses from experts and have suitable academic qualification to understand the SC concepts and KS practices.

Step 2: Framing the Criteria of Evaluation and Survey Instrument

Developing criteria set for evaluation is vital. However, the criteria have the difficulty of complex relationships within the criteria set. The DEMATEL is sufficient to be implemented in this analysis to obtain a structural model separating evaluation metrics into the cause and effect group.
Step 3: Obtaining the Answered Instrument of the Study

In order to improve the credibility of the section on criteria and to depict the entire SC innovation and KS practices in the industry, the expert committee must be conducted as two parties.

Step 4: Transformation of the Linguistic Variables into Crisp Values

According to the feedback obtained from the respondents, the linguistic scale must first be translated to a triangular fuzzy number. And after that, these fuzzy numbers need to be translated back to a crisp score and apply the fuzzy calculations in equations (5)–(9), defuzzified and summarized as the crisp value of $\tilde{\omega}_{ij}^k$. Furthermore, the crisp value is formed of the vector for the initial direct relation.

Step 5: Analysis of the Criteria into Cause and Effect Graph

From equations (10)-(12) the normalized direct relation matrix $Q$ is attained, similarly, a cause and effect graph is plotted from computed values of equations (13)-(15). Figure 1 shows the stepwise evaluation of fuzzy DEMATEL method.

4. DATA COLLECTION FINDINGS

4.1 Eminence and Facts of the Case

To carry out an exploratory research, case studies are more practical because it implicates first-hand knowledge, in-depth and comprehensive examination of studied stimuli. In addition, case studies are accepted as suitable and worthwhile acquiring evidence in subjective and under multifaceted relational criteria where limits are frequently unclear. This study adopts a case study approach to gather the data for analysis.

The automotive sector is the most progressive sector of Pakistan. According to the economic survey 2018-2019 (Government of Pakistan), the contribution accounts for 4% of total GDP. According to PAMA (Pakistan Automotive Manufacturers Association), there are two leading contributors in the automotive industry; Suzuki and Toyota, as well as running a supplier base of 400 approximately. This supplier base of local manufacturers represents the struggles of technology and knowledge transfer among business partners. One shared value for innovation and robustness among these companies is lean manufacturing practices. In a real-world scenario, KS is documented as a crucial enabler of lean SC performance (Chen et al., 2017).

Besides the justification above for carrying this study, a gap in the subject area was also discussed in the earlier part of the literature review. Therefore, the study results would add value to the literature and practical implication for organizations.

4.2 Examining the Case

We consider two MNCs, Toyota and Suzuki for our case. At least seven employees from management roles were selected from each company to participate in this research. The respondents were asked to specify the relationship among the list of barriers (criteria) based on fuzzy DEMATEL relationship matrix. For this study, twelve barriers (criteria) were selected based on inputs from the literature review and committee members discussion comprises of academia-industry experts. Next, an initial questionnaire was constructed using selected barriers. An explanation was also added to each barrier to mitigate any further ambiguity of the respondent’s understanding. The questionnaire was first tested by two academia and one industry expert from the studied country to check on the understandability...
and clarity of language in order for the respondents to answer them appropriately. Finally, the questionnaire was delivered to the respondents and requested them to rate causal-interrelationship between the barriers following the linguistic scale (Table 1). For our empirical analysis, a total of 19 responses were received, nine from Toyota and eleven from Suzuki. These responses were then test run following the steps in methodology:

Figure 1. Stepwise evaluation of fuzzy DEMATEL (Wu et al., 2015)
(1) The collected evaluation by respondents was transformed into TFNs and perform normalization to a crisp value using equations (5)-(7).
(2) The evaluation of causal-interrelationship between the barriers from 19 respondents was aggregated to form a particular judgement by equation (9) to a crisp value of $\omega_{ij}$. Further, the crisp value of VE barriers from fuzzy assessment formed the initial direct relation matrix referring in Table 2.
(3) Acquired normalized direct relation matrix by equations (10)-(12). Then apply equation (13) to transform it to total direct relation matrix shown in Table 3.
(4) Hence, by using equations (14) and (15), we acquired Table 4 that denotes prominence and relation axis of cause and effect group. The (D+R) horizontal axis can be labelled as “Prominence” or significance of criterion, and it is obtained by adding D and R. Similarly, (D-R) vertical axis represents “Relation” is attained by subtraction task D-R.
(5) The Table 4 then lead to form the cause and effect diagram, which is Figure 2. The positive or negative value of (D-R) distributes criterion in cause and effect group, i.e. negative (D-R) indicates the effect, and positive (D-R) denotes the cause. So the values of (D+R) and (D-R) plot barriers (criteria) into four quadrants. The quadrant I “driving factor” are those who possess higher “prominence” and “relation” value; quadrant II “voluntariness” represents criteria with low “prominence” though higher “relation” significance; quadrant III “independent” that has no relation with the system; and quadrant IV referred to “core problem” should have been solved, and may not openly improve the condition (Chuang et al., 2013; Lee et al., 2010).

The findings are revealed in the causal diagram (Figure 2) that segregated 12 barriers (criteria) of VE for KS into four quadrants. These barriers were identified into the cause and effect category, kindly refer to Table 4.

<table>
<thead>
<tr>
<th>Table 1. Fuzzy linguistic scale (TFNs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abbreviation</strong></td>
</tr>
<tr>
<td>NI</td>
</tr>
<tr>
<td>VL</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>HI</td>
</tr>
<tr>
<td>VHI</td>
</tr>
</tbody>
</table>

Illustrating the cause and effect diagram (Figure 2), alignment of culture (A1) is the only criterion lies on the driving factor quadrant implies that organizational culture alignment with KS values should be the prime concern for organizations to invest and prioritize to gain more innovative capabilities in the SC. In parallel, focusing on the driving factor, the organizations should also prioritize criteria that fall under voluntariness. In this study, lack of leadership commitment (A2), lack of employee involvement and autonomy (A3), aggressive treatment of managers (A4) and lack of employee welfare, trainings and development (A6) are voluntaries. The criteria in quadrant three are least correlated to our study and are independent; (A5), (A7) and (A8). Finally, the core problems are lack of feedback on the quality of shared knowledge (A9), lack of trust on peers (A10), lack of trust on management (A11) and fear of losing job, prominence and opportunistic behavior (A12) must be solved. Also, the effect of driving factor (A1) on each criterion is drawn using lines between them, where the weakest effect is (A2), followed by medium effect (A3) and strong effect (A12).
Concluding the results of this study, organizations nurture VE for KS to boost SC innovation must focus on the alignment of existing culture (A1) with KS values. For example, Toyota practices “Yokoten” as a norm for sharing better ideas implemented by any team or employee with others across the SC, including partners. The more likelihood is working on (A1) would positively affect the voluntariness criteria group. Moreover, the organizations should also emphasize on building trust on management (A11) and fear of losing job, prominence and opportunistic (A12) behavior as they reflect higher D+R values in effect criteria group. This study’s outcome provides worthy evidence to support the causal relationship between VE barriers in the automotive sector of Pakistan to gain benefits of KS to innovate the SC. Moreover, the same approach can be implemented for different manufacturing industries worldwide because the idea of practicing VE lacks in previous studies for KS, as discussed in the literature.

Table 2. DEMATEL initial direct relation matrix

<table>
<thead>
<tr>
<th></th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
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<th>A6</th>
<th>A7</th>
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<tbody>
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<td>0.4171</td>
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Table 3. Total DEMATEL relation matrix

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<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
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</table>
5. MANAGERIAL IMPLICATIONS

This study is conducted to examine the causal relationship of VE barriers in the context of KS for SC innovation. The findings of the case study of Toyota and Suzuki in Pakistan indicate numerous managerial implications.

Table 4. The prominence and relation axis for cause and effect group

<table>
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<tr>
<th>Criteria</th>
<th>D (sum)</th>
<th>R (Sum)</th>
<th>D+R</th>
<th>D-R</th>
</tr>
</thead>
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<td>3.0979</td>
<td>3.0979</td>
<td>(1.3036)</td>
</tr>
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</table>

Figure 2. Cause and effect diagram
Firstly, the utmost cause and driving factor of negating VE for KS is the alignment of organizational culture (A1) that supports KS as a value. Culture (A1) has an effect on all the criteria (Table 4). The findings from our case examination at Toyota and Suzuki are not fully aligned with the past literature. Both companies are Japanese MNCs and focused more on collectivism and healthy knowledge culture. The collectivism encourages KS and innovative behavior (Pian, Jin & Li, 2019) and result (A1) negates this statement. AlShamsi and Ajmal (2018) suggests culture as critical factor of KS. Therefore, the managers should critically analyze existing culture and take necessary steps to align culture with KS practices.

Secondly, the significant cause criteria followed by (A1) is lack of employee welfare, trainings and development (A6), and employee involvement and autonomy (A3). Employees consider safety as a prime well-being value. Insecure feeling on welfare and career prospect affects commitment with the company (Liao, Chen & Hu, 2018). The involvement creates sense of being valued, and also eliminates unwillingness to accept change and enables the alignment of culture to KS culture (Aslam et al., 2018). According to Gagné et al. (2019), the lack of autonomy made employee less comfortable and demotivated them from sharing experiences. Henceforth, managers ought to involve employees and provide ample autonomy.

Finally, lack of leadership commitment (A2) is the most influential criteria that requires managers to develop protocols, mechanisms and policies to support KS, notwithstanding a better leader must train members of the team and initiate practices to promote awareness, morale and confidence. The dearth of leadership would cause the rise-up of more barriers of KS (May & Fombad, 2019). The leadership support or commitment (A2) is strong enough to support (A1) but also influences (A6) (Maitlo et al., 2019). Moreover, fear of losing job, prominence and opportunistic behavior (A12) is an eye-catching core problem that requires an ultimate solution. Peltokorpi (2006) articulates that collectivism has harmful influence, i.e. factionalism, which could result in competition and power struggles among local teams. It damages cooperative behavior. Thus, the managers have to eradicate rivalry and self-interest among the team.

6. CONCLUSION

VE creates a sense of coordination and harmonization to share the knowledge that marks SC innovation. The eminence of KS for SC innovation is undeniable in the way to initiate development in products, services and operations. Many researchers endorsed the impact of KS on innovation. The study’s findings focus on providing recommendations for companies to remove hindrances in the flow of information and knowledge by urging the natural attribute of employees and SC partners, i.e., VE.

The case examinations of MNCs, Toyota and Suzuki give recommendations for the manufacturers. The alignment of culture is the driving force to nurture VE in employees and SC partners to benefit firm in achieving and sustaining SC innovation. The organizational culture governs values for people who ultimately reflected in their behavior. For instance, the perception of losing authority and credibility by sharing information and knowledge would avoid people doing so. Therefore, the alignment of organizational culture is a must. Above and beyond, the companies should also ensure leadership commitment and put effort into eradicating the fear of losing job, self-interest and rivalry to let the proposed idea workable.

This paper’s academic contribution is that it examines the notion of VE for KS in manufacturing companies to reach and maintain SC innovation, though VE has mostly focused by researchers in social issues such as sports and welfare. The study opens a new dimension of measuring VE in organizations, since the VE phenomenon exists but never been evaluated before. The measurements of the criteria (barriers) could also serve as an assessment framework. Furthermore, the causal relationships via fuzzy DEMATEL among VE barriers (organizational culture, climate, and trust) determine their importance and prominence.
Yet, the study concluded with some limitations. First, the study targeted two Japanese MNCs with collectivist culture to examine VE barriers, and further research can be carried out on industries from different sectors in different countries. Secondly, the study aims to practice voluntary behavior for unrestricted sharing of knowledge to sustain the SC innovation. A comparative case study on the effectiveness of VE and incentive base system can be undertaken in future to widen the scope of the study.
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