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Article

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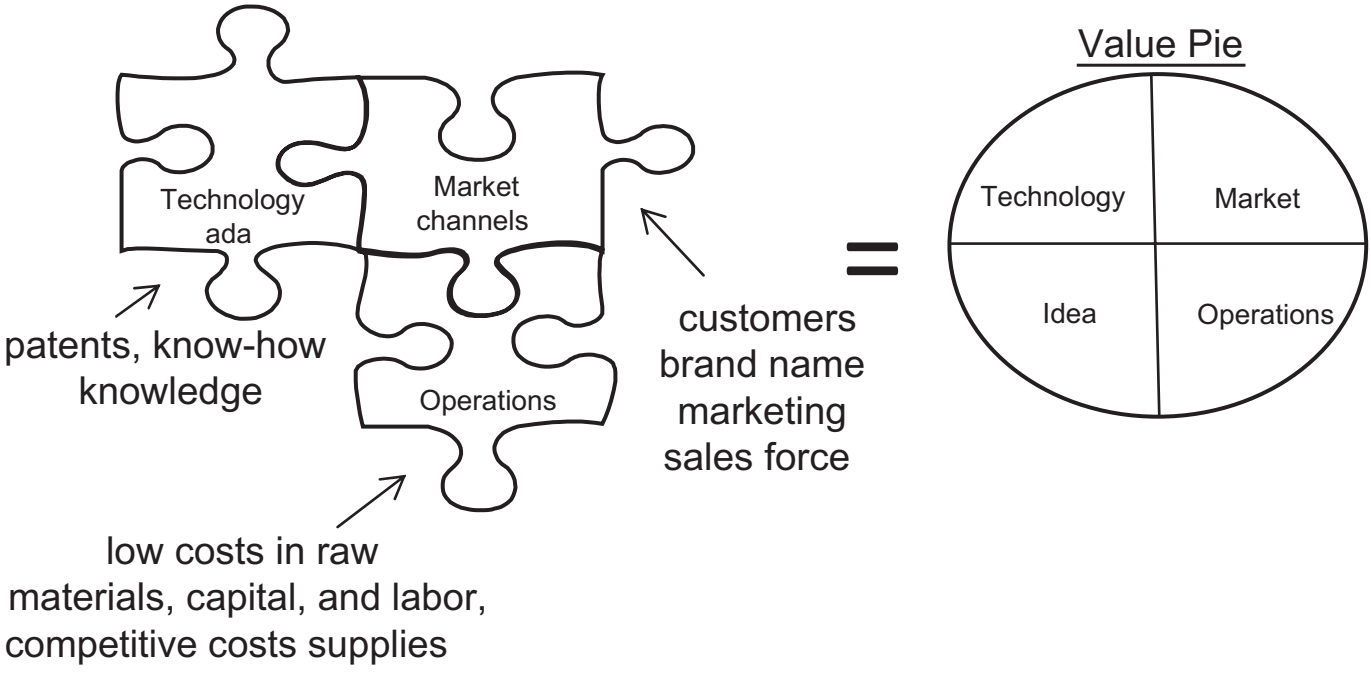

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Firm's knowledge creation structure for new product development

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Abstract: Knowledge has many different characteristics and scholars in epistemology, economics and management have dealt with them ever since knowledge has emerged as the leading source of firms' competitive advantages. New product development requires new ideas and new ideas are stemming from knowledge. Knowledge originates from tacit knowledge. Therefore, firms need to enact tacit knowledge. Enactment takes different forms depending on the context of knowledge and organizational characteristics. This paper conducts an in-depth literature review on the nature of knowledge and knowledge creation structure and investigates how The Dow Chemical Company uses a knowledge creation structure to elicit tacit knowledge and exploit knowledge for new product development. The Dow Chemical Company is known as one of the leading innovative firms in the world. We believe that this case enriches research on knowledge creation and new product development although it has limitations in generalizing its findings and practices. In solidifying the knowledge-based theory of the firm, we need a multi-dimensional approach such as a survey, case study, and theory development. This study develops a knowledge creation theory and apply it to the real business case.

Subjects: Business, Management and Accounting; Economics, Finance, Business & Industry; Information / Knowledge Management

Keywords: knowledge creation; knowledge management; knowledge creation structure; competence creation; tacit and explicit knowledge; collaboration; stakeholders; knowledge scouting

1. Introduction

Knowledge has emerged as the most important source of a firm's sustainable competitive advantage. Considering the importance of the subject, it is not surprising to witness a plethora of research, with a number of different perspectives from which researchers and practitioners have approached

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Hong Y. Park is a professor of Economics and Braun Research Fellow, College of Business and Management at Saginaw Valley State University, USA. He has done extensive research on theories of the firm, organizational theory, and corporate strategy. He is lately involved in research on knowledge, creativity, innovation, and entrepreneurship. Firms need to make innovation to achieve competitive advantage. Innovation requires new ideas and knowledge is the source of new ideas. Knowledge is tacit and requires enactment for new product development. Proper knowledge creation structure is essential to elicit tacit knowledge.

PUBLIC INTEREST STATEMENT

The organization needs to design a structure of knowledge creation to elicit knowledge from organizational members, stakeholders, scientists, and competitors. This paper reviews the nature of knowledge and factors that are necessary for effective knowledge creation structure. This paper examines a case of company's knowledge creation structure and new product development based on the knowledge creation theory. The paper develops a knowledge creation model which incorporates both structure and individuals' responses to the structure, providing a relatively more complete picture of the knowledge creation process in the work place.

the management of knowledge. One notable recent development is that scholars in knowledge management began to elicit knowledge from many different sources.

Obviously, managers have been making deliberate efforts to manage the knowledge of their organizations' work force. According to Hislop (2009), they use a wide range of methods in knowledge management, such as structuring organizations in particular ways, or using particular culture and people management practices and incorporating information and communication technologies (ICTs). The choice of these methods may depend on the nature of knowledge, and the use of a particular ICT is applicable to explicit knowledge management.

This paper focuses on knowledge creation with an interactive perspective between the structure and individual (agent) behavior in organization. Also, in particular, this study assumes that tacit knowledge is a key element in knowledge creation. Structures of organization and cultures are applied to knowledge creation, which converts tacit knowledge into explicit knowledge. Many studies on knowledge creation have focused on the effects of structures on knowledge outcomes.

Recently, scholars are beginning to pay attention to knowledge creation at the micro level of individuals (Felin, Zenger, & Tomsik, 2009). This micro approach to knowledge creation relies on the belief that knowledge is personal, subjective, context specific, and embodied in individuals (Felin & Foss, 2006; Nonaka & Toyama, 2003). How do organizational structures and cultures affect an individual's behavior and interactions? How do they elicit tacit knowledge from individuals? Studies on the effects of structures and cultures on individuals' decisions about knowledge sharing/hoarding, interactions among individuals, and individuals' activities and knowledge outcomes are proposed as foundations of knowledge creation. However, there is a dearth of research on the micro perspective (Felin & Foss, 2005, 2006) and the integration of the structure–agent approach. This study is an attempt to study the micro foundation of knowledge creation and the integration of a structure–agent approach based on a practice of a firm.

Feldman and Orlikowski (2011) point out that practice theory as it is practiced in relation to organizational phenomena is an emerging field. They situate practice theory in relation to three ways of studying practice: "an empirical focus on how people act in organizational contexts, a theoretical focus on understanding relations between the actions people take and structures of organizational life, and a philosophical focus on the constitutive role of practices in producing organizational reality" (p. 1240). According to Bourdieu (1977), "practices are no more than executions …. Or the implementing of plans" (p. 96). Executions or implementing plans involve activities and Hislop (2009) defines practice as purposeful human activity. How does a firm implement knowledge creation plans? We can study practices of a firm to answer this question.

Knowledge creation structures may vary depending on organizations (place) and time. However, knowledge creation structures today converge more easily because of the globalization of the world economy as well as ICT. The currently emerging knowledge creation structure, called "ideation," is defined as "the process of generating or conceiving ideas and concepts that may be useful for attaining some desired state or outcome." Simpson (2008) defines it more simply and concretely: "Ideation is the systematic search for targeted opportunities, and new markets, and new services" (p. 1). Park, Chang, and Lee (2011) have illustrated typical processes that knowledge creating companies follow in developing a new competency.

The Dow Chemical Company, a leading innovative firm in the world, offers a practice for knowledge creation. This paper examines a knowledge creation practice based on the case of the Dow Chemical Company (Whiteman, 2013). In particular, we examine a knowledge creation practice of The Dow Chemical Company from a theoretical knowledge creation perspective. It would be interesting to learn the practice of knowledge creation and exploitation of knowledge in a leading innovative firm for new competency creation. This section is based on a presentation by Whiteman (2013) and an in-depth interview with Mr Whiteman who is the president of Dow Global Technology, Inc.

This paper consists of seven sections. Section 2 discusses the nature of knowledge and Section 3 examines the relationship between a knowledge creation structure and agents. Section 4 builds knowledge and competence creation model. Section 5 examines the business case of the Dow Chemical Company. We discuss the Dow's case in Section 6 and conclude the paper in Section 7.

2. Nature of knowledge

We employ several theoretical frameworks for our knowledge creation model. First, Polanyi's (1966) tacit and explicit knowledge are the basis for discovery of knowledge. Second, Whitehead's (1929) process and reality offer a framework for dynamics of the knowledge creation process and creativity. Third, the social theory (Bourdieu, 1977, 1990; Coleman, 1986, 1990; Giddens, 1984; Sewell, 1992) is suitable for the analysis of the relationship between the structure and individual (agent) behavior. Fourth, dynamic managerial capabilities integrate theories and practices to create and maintain a firm's competitive advantage (Bourdieu, 1977; Helfat et al., 2007; Schiuma, 2009) and develop a knowledge creation model (Kogut & Zander, 1992; Nonaka & Takeuchi, 1995).

The sources of new knowledge elucidated by Polanyi (1966) and Whitehead (1929) are tacit knowledge and lived experience; personal knowledge and employees' experiences are sources of this knowledge. Knowledge is created by a team in an organization as team members interact in the knowledge creation process. This raises several issues in team production. The structure of the organization is designed to address these issues because it has effects on their behavior. Giddens' structuration theory (1979, 1984) may offer a framework for explaining the relationship between structure and agent in knowledge creation, as it is concerned with understanding the activities of knowledgeable human actors and the structuring of social systems.

2.1. Tacit and explicit knowledge

Most knowledge scholars agree that knowledge has multi-dimensions such as tacit and explicit knowledge (Kogut & Zander, 1992; Lam, 2000; Nonaka & Takeuchi, 1995; Polanyi, 1966); ontology of knowledge (Lam, 2000); dispersed knowledge (Hayek, 1945; Tsoukas, 1996); individuals and the institution (Coleman, 1986, 1990; Felin & Foss 2005, 2006; Foss & Mahnke, 2005; Nelson & Sampat, 2001); knowledge sharing among employees (Argote & Ingram, 2000); processes of reflexivity and direct social interaction (Bourdieu, 1977, 1990; Nonaka & Takeuchi, 1995; Tsoukas, 2009); access costs to knowledge (Mokyr, 2000); communities of practice (Brown & Duguid, 1991; Cook & Brown, 1999; Guzman, 2009); the evolution of knowledge creation practices (Bourdieu, 1977; Nelson & Winter, 1982; Popper, 1982; Schiuma, 2009); and know-how and know that (Ryle, 1946, 1949). Among these dimensions and characteristics of knowledge, we focus the dimension of tacit and explicit knowledge and dispersed knowledge.

Characteristics of tacit and explicit knowledge (Polanyi, 1966) and dispersed knowledge (Hayek, 1945) have been discussed most frequently in knowledge and capability creation because understanding them is essential in knowledge management. The sources of new knowledge elucidated by Polanyi (1966) and Whitehead (1929) are tacit knowledge and lived experience; personal knowledge and employees' experiences are sources of this knowledge.

Polanyi's (1966) statement on tacit knowledge tells the complexity of the issues in knowledge creation. He states that we can know more than we can tell (p. 4). For Polanyi (1966), explicit knowledge is rooted in tacit knowledge and tacit knowledge is the origin of knowledge. The knower acquires tacit knowledge by experience (indwelling) and engages in discovery of knowledge. Individuals' efforts contacting hidden reality leads to a discovery of new knowledge. Polanyi (1966) argues that indwelling is the proper means of knowing (p. 16). Polanyi uses the notions of intuition and intimation of hidden reality. For Polanyi (1966), intuition is making a guess and guessing correctly. Individuals who are indwelling in their jobs develop a good intuition and easily detect intimation from the hidden reality. As a knower (employee) cumulates tacit and explicit knowledge, the knower improves the discovery of knowledge. According to Schön (1983), tacit knowledge is rooted in action,

procedures, routines, commitment, ideas, value, and emotion. The embeddedness of knowledge in individuals and action is one of the central characteristics of tacit knowledge and this characteristic of tacit knowledge requires an approach, which integrates individuals and organizations.

Tacit knowledge is available and can become an important source of competitive advantage when the company mobilizes it for innovation in products, processes, and services. Knowledge is created by a team in an organization as team members interact in the knowledge creation process. This raises several issues in team production such as hoarding and sharing and incentives compatibilities among team members. The structure of the organization needs to be designed to address these issues because it has effects on agents' behavior.

2.2. Knowledge creation and creativity

We can adopt Whitehead's process philosophy for the process of knowledge creation. Whitehead's philosophy is known as very complex. Scholars help us comprehend his main themes (Mesle, 2008; Sherburne, 1966). Whitehead (1929) contends that our world and our lives are dynamic and interrelated. Reality itself is a vast macro process embracing a diversified manifold of micro processes, novelty, innovation, and the emergence of new focus as inherent features of the cosmic scene. Whitehead, known as the philosopher of organism focuses on "becoming" and sees the world as organic. Reality in Whitehead's universe is interconnected, relational, and dynamic.

For Whitehead, "all knowledge is conscious discrimination of objects experienced" (Whitehead, 1933, p. 176). He argues that knowledge is the subjective form of the interplay of knower with known. Whitehead also indicates that the notion of mere knowledge is a high abstraction, and that conscious discrimination itself is a variable factor present only in more elaborate occasions of experience. The basis of experience is emotional and sensual. He accepts that "all knowledge is derived from, and verified by, direct intuitive observation" (Whitehead, 1933, p. 177). According to Desmet (2009), "Whitehead's analysis of sense experience stems from the idea that our experience is a stream of experiential moments in which each moment is initially determined by its past" (p. 4). Desmet points out that a vague feeling of all past things exercises a causal influence on the present moment, so that the past is preserved in the present and the past affects the future.

Whitehead attempted to integrate the theory, experiment, and sensual experience (Desmet, 2009). He places emphasis on experience and distinguishes three modes of perception in each of our perceptual moments of experience: the pure modes of causal efficacy, presentational immediacy, and the mixed mode of symbolic reference (Whitehead, 1929, pp. 120–121). When applying this model, employee perceives immediate presentation and efficient cause for their observations, forming perceptions on the interplay between causal efficacy and presentational immediacy. As there are possibilities of errors in symbolic reference on the interplay between causal efficacy and presentational immediacy, employees' conscious reflexive monitoring of errors can be valuable for knowledge creation. Therefore, new knowledge based on employees' experience requires verification and sharing experiences among employees. Employees' experiences present many selection alternatives for knowledge creating firms.

Creativity in Whitehead (1929) likewise has a parallel in knowledge creation. Knowledge scholars such as Nonaka and Takeuchi (1995) follow Whitehead's philosophical tradition of integrating the phenomenal and noumenal world. Mesle (2008) points out that Kant distinguishes between the noumenal world—the world as it is itself—and the phenomenal world—the world as actually experienced by us. The question is this: if we cannot know anything about the noumenal world, how can we know that the noumenal world exists or that it does or does not include space, time, causality, and substance? According to Mesle, Whitehead argued that the world "out there," the world "in itself" does have space, time, and causality and that we can know this because we experience ourselves as part of that larger causal world through perception in the mode of causal efficacy (Mesle, 2008, p. 61). Our sense experience is unique and involves interpretation, as Mesle (2008) makes it clear:

> Every act of experience has its own unique perspective, its own "actual world." No two events arise out of exactly the same spatial-temporal situation. Much less do any two moments in a human life arise out of exactly the same context? Certainly, no two people share the same biography. Furthermore, each new experience involves interpretation of the received data. (Mesle, 2008, p. 59)

From this perspective, every employee's experience offers a perspective on the actual world, and every interpretation involves an interpretation of that world. Thus, diversity of employees' experience and interpretations of the actual world are sources of creativity, and as Whitehead states creativity is the principle of novelty:

> Creativity is the universal of universals characterizing ultimate matter of fact. It is that ultimate principle by which the many, which are the universe disjunctively, become the one actual occasion, which is the universe conjunctively. It lies in the nature of things that the many enter into complex unity. "Creativity" is the principle of novelty. (Whitehead, 1929, p. 21)

Whitehead's (1929) concept of concrescence illustrates how the new entity becomes concrete by many entities growing together. Fieser and Stumpf (2012) point out that Whitehead (1929) visualized reality as a continual process in which actual entities are constantly becoming. Creativity then is the ultimate principle by which the many enter into complex unity.

The experiences of employees, customers, and competitors, reported as data, can be a basis of new knowledge creation. The experiences of these stakeholders present many possibilities (eternal objects for Whitehead), and the organization needs to establish a process to identify and select the relevant possibilities. When a good selection is made, the result is profitable for the organization. For Whitehead, "there are two species of process, macroscopic process, and microscopic process. The macroscopic process is the transition from attained actuality to actuality in attainment while the microscopic process is the conversion of conditions which are merely real into determinate actuality [i.e. it is concrescence]" (Whitehead, 1929, p. 326). However, current scholars argue they are species of one process. According to Sherburne (1966), Whitehead's process is the creative thrust from many to one, producing a novel entity that is other than the many that gave rise to it, and thus, part of a new many that in turn is productive of new novel entities. This rhythmic alteration between

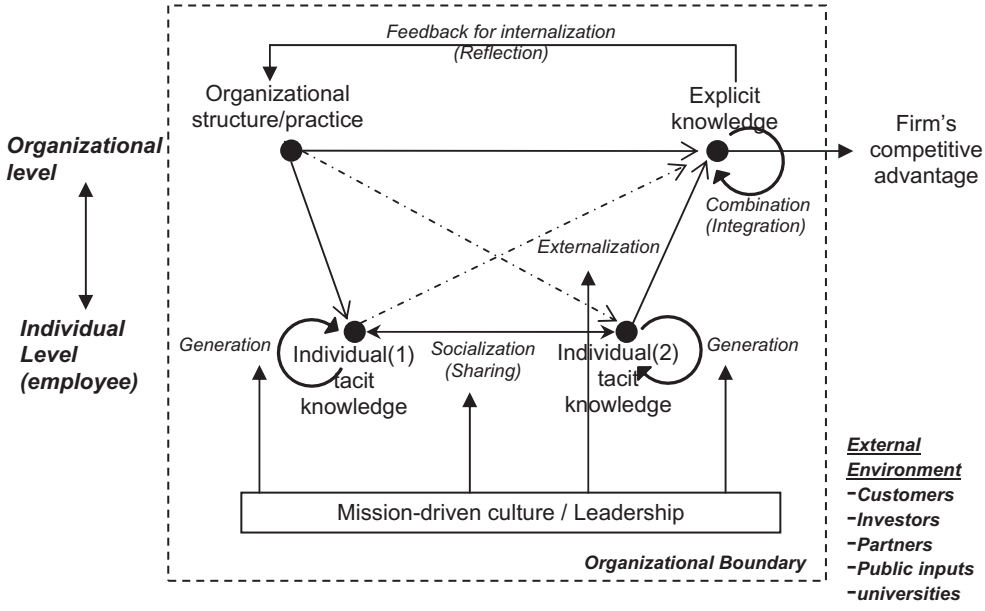


Figure 1. Conceptual framework: micro–macro integrative approach to knowledge creation.

many and one is a process. Experiences of many stakeholders in the organization contribute to the creation of a novelty. Therefore, the stakeholders in knowledge creation (see Figure 1) need concrescence because they are all connected, as in Whitehead's philosophy of organism or process.

Argote and Miron-Spektor's (2011) organizational learning model includes the task performance experience as sources of knowledge. She states that "experience is what transpires in the organization as it performs its task" and "experience interacts with the context to create knowledge" (p. 1124). The context has two dimensions: environmental context and latent organizational context. Our model in Figure 1 includes both dimensions. A new innovation in product, process, and service may require knowledge from employees, suppliers, customers, academicians, and competitors, as well as other relevant stakeholders. In the long run, the organization cannot grow at the cost of stakeholders. This requires the formation of a network with relevant stakeholders and collaboration among stakeholders has become increasingly important in knowledge creation and new product development. Samsung (Korean Business Group) increased collaboration with suppliers (Song, 2013). We have seen a paradigm shift in the US firms for their dealing with suppliers and increased suppliers' involvement in new product development (Park, Reddy, Shin, & Eckerle, 1996; Park, Surender Reddy, & Jurn, 2001).

One must understand the principle of creativity to see how concrescence and transition of fluency are species of one process. Sherburne (1966) points out that the notion of creativity is crucial to an understanding of process. Whitehead (1933) states that "creativity is the actualization of potentiality, and the process of actualization is an occasion of experiencing" (p. 179). The basic presupposition of Whitehead's system is becoming and ongoing. In this framework, an organization's knowledge creation is becoming of its new product, process, and service that make the organization ongoing. Thus, the process of knowledge creation is actualization of the experiences of stakeholders in the organization.

The organization needs to design a structure to elicit tacit and personal knowledge from individuals. We elaborate the structure and agents (individuals) in the next section (Section 3).

3. Knowledge creation structure and agents

We argue that Giddens' duality of structure (1979, 1984) can be adopted for the analysis of the actors and structure of knowledge creation. For Giddens (1979, 1984), structures are rules and resources. He regards the rules of social life as "techniques or generalizable procedures applied in the enactment/reproductions of social practices" (1984, p. 21), considering three dimensions of social structure in his structuration theory: signification, legitimation, and domination. In knowledge creation, the signification (meaning) structure is shared rules, concepts, and theories which actors can draw on to make sense of knowledge creation; each actor makes sense of what others say and do in his interactions with other members by interpreting them. Each actor also receives intimation from reality, as stated by Polanyi (1966) and Whitehead (1929). Sharing and communicating with team members can be helpful in making sense of and drawing meaning from each actor's experience and the intimation that each actor is receiving from the hidden reality. As interactions with team members clarify concepts and theories, they help create new knowledge.

Macintosh and Scapens (1990) draw on Giddens' (1979, 1984) structuration theory as their framework for management accounting. According to Macintosh and Scapens (1990), legitimation involves the moral constitution of interaction. They argue that the legitimation structure is mediated through norms and moral codes which sanction particular behaviors, and they further point out what comprises the legitimation structure:

> It comprises the shared sets of values and ideals about what is to be regarded as virtue and what is to be regarded as vice; what is to count as important and what is to be trivialized; what ought to happen, what not to happen. (Macintosh & Scapens, 1990, p. 460)

Since knowledge is tacit and lived experience (Polanyi, 1962; Whitehead, 1929) and locked in the human mind (Kim & Mauborgne, 1998), the decision to share or hoard knowledge has been the classical dilemma for exploiting knowledge in an organization. Therefore, creating shared sets of values and ideals among actors in an organization is crucial for organizational knowledge creation. This legitimation structure lays a theoretical ground for the importance of inter-personal trust among members in a knowledge creation team.

Giddens argues that domination depends upon the mobilization of two distinguishable types of resources (1984, p. 33): Allocative resources and authoritative resources. Allocative resources refer "to material resources involved in the generation of power, including the natural environment and physical artifacts; allocative resources derive from human domination over nature" (Giddens, 1984, p. 373). Authoritative resources refer to "non-material resources involved in the generation of power, deriving from the capability of harnessing the activities of human beings; authoritative resources result from the domination of some actors over others" (Giddens, 1984, p. 373). According to Macintosh and Scapens (1990), both types of resources facilitate the transformative capacity of human action (power in the broad sense), while at the same time, providing the medium for domination (power in the narrow sense). They further point out that power in its broad sense is the ability to get things done and to make a difference in the world. Because employees or subordinates can exercise significant power in the knowledge creation process, managers' domination over employees tends to be more congenial than domineering because of this nature of knowledge. A study by Srivastava, Bartol, and Locke (2006) found that empowering team leaders and employees relates positively to both knowledge sharing and team efficacy.

Giddens' (1979, 1984) focus on the understanding of human agency and social institutions use human agents and actors interchangeably. According to Sewell (1992), Giddens places a great deal of weight on the notion that actors are knowledgeable, defining knowledgeability as "everything which actors know (believe) about the circumstances of their action and that of others, drawn upon in the production and reproduction of that action, including tacit as well as discursively available knowledge" (p. 375). Actors become knowledgeable about knowledge creation structures as they develop a set of dispositions on structures, which Bourdieu (1977) refers to as habitus. For Bourdieu (1977), habitus is a system of dispositions (lasting, acquired schemes of perception, thought, and action). The individual agent develops these dispositions in response to the objective structure that the individual encounters. He argues that agents inculcate objective social structures into the subjective, mental experience of agents. Because a habitus tends to favor the particular social arrangement of society and reproduce the very structure of society, Bourdieu insists that sociologists must pay conscious attention to the effects of their own position on distortion or prejudice. This reflexivity can impel sociologists to correct their biases and prejudices. Ösbilgin and Tatli (2005) review Bourdieu's work and argue that his work can contribute to organization and management studies in three substantial ways:

> through (1) offering a conceptual framework for a multilevel research agenda in organization and management studies, (2) presenting an epistemological and methodological framework for tackling issues of reflexivity in the research process, and (3) proposing a methodological and epistemological way to overcome the dualities between structure and agency and objectivism and subjectivism. (Ösbilgin & Tatli, 2005, p. 855)

Therefore, the reflexivity of individuals can be a key factor contributing to knowledge creation and changes in structures.

Giddens' structuration theory provides a framework for knowledge creation structures and agency. If we assume that there are two employees in a knowledge creation team, both have tacit knowledge and lived experiences from their respective jobs. They have acquired knowledge from customers, investors, partners, competitors, and the scientific community. Therefore, individuals engaged in knowledge creation are knowledgeable, conscious, and reflexive. Individuals can also anticipate possible future states, based on their abilities to detect intimation from the hidden reality

in their fields (Polanyi, 1969). They can anticipate change in technologies, markets, and regulations. A knowledge creation team consists of individuals with these traits who participate in knowledge creation. According to Fuchs (2003), creativity is the ability to create something new that seems desirable and helps to achieve defined goals. Based on anticipation of the future, the knowledge creation teams design/create new products, processes, and services and provide solutions to problems. Individuals' participation in knowledge creation can be regarded as a micro foundation; their interactions result in new knowledge. Thus, a new knowledge creation structure may emerge from actions, interactions, and reflexive monitoring of individuals. We can observe these phenomena from innovative firms such as Dow Chemical, Apple, Google, and Samsung.

4. Knowledge and competency creation model

The knowledge and dynamic capabilities creation models by Nonaka and Takeuchi (1995), Kogut and Zander (1992), and Zollo and Winter (2002) have some common characteristics of becoming, and methods of converting experiences to new products/processes/services. Hargadon and Fanelli (2002) argue that "the conversion of latent knowledge to empirical knowledge refers to the application of knowledge latent in individuals to generate a physical or social artifact" (p. 295). They further explain that "the conversion of empirical knowledge to latent knowledge refers to the reflexive experience of individuals within the organization" (p. 295), arguing that the generation of new knowledge or the successful replication of old knowledge depends on the cyclic interaction between latent knowledge and empirical knowledge. This cyclic interaction continues in the ongoing process of knowledge creation.

In a similar vein, Bhaskar (1975) introduces two dimensions in knowledge production: the transitive dimension (the production of knowledge from and by means of knowledge) and the intransitive dimension (the independent existence and activity of causal structures and things). Bhaskar (1975) points out that knowledge in the transitive dimension is socially produced and the objects of knowledge in the intransitive dimension exist and act independently of men although their existence and/or activity depend implicitly or explicitly upon men. He argues that scientists try to discover the reasons for things and events, patterns and processes, sequences and structures, and they need to understand both "a concept of the transitive process of knowledge-production and intransitive objects of the knowledge they produce: the real mechanisms that generate the actual phenomena of the world, including as special case on our perceptions of them" (p. 62). Bhaskar (1975) argues that science must be conceived as an ongoing process of transformation, continually or essentially in motion, in an attempt to capture (i.e. penetrate and describe) the stratification of the world. In capturing the concept of the ongoing process of transformation, Nonaka and Toyoma (2003) propose dialectics in knowledge creation. According to them, dialectics is a method of thinking and acting and a way/process to approach a reality to find truth in it. They point out that the dialectic tries to approach the elusive "absolute truth" through the process of examining and denying the series of "relative truth," although the absolute truth may never be found or may never exist. They emphasize that the process is more important than reaching the absolute truth or not. Therefore, knowledge creation is dynamic and in motion.

Recent developments in knowledge asset dynamics (Moustaghfir, 2009; Schiuma, 2009) illustrate the process of knowledge asset flow and also capture the dynamic process of organization knowledge and value creation capacity. Schiuma (2009) points out that "knowledge assets interact with each other affecting their mutual transformation and the development of organizational capabilities" (p. 294). The organization needs to design a structure to elicit tacit and personal knowledge from individuals.

4.1. Factors affecting knowledge creation

As stated before knowledge is tacit, dispersed personal, and embedded in individuals. Because of these unique characteristics of knowledge, the organization is required to enact knowledge (Weick, 1977). The organization needs to design a structure of knowledge creation to elicit knowledge from organizational members, stakeholders, and competitors. Once a knowledge creation structure is

constructed, it will serve the functions of structure discussed above. The structure needs to include several factors to elicit knowledge from individuals and to create knowledge for organizational competences as discussed above.

(1) Individuals in an organization need to have opportunities to propose ideas as they discover new knowledge. Knowledge is context specific in time and place and difficult to capture the same knowledge after a passage of time. Knowledge should be reported as individuals experience it (Polanyi, 1966; Whitehead, 1929).

(2) The knowledge creation team should have diversity in education and personal traits because diversity and intensity are known for good in creating new knowledge (Hofstede, 1980; Mokyr, 2000).

(3) Individuals should have opportunities to interact and share knowledge because interactions among members of the organization create new knowledge (Argote & Miron-Spektor, 2011; Baer, Oldham, Jacobsohn, & Hollinghead, 2007; Tsoukas, 2009).

(4) The structure needs to be conducive for knowledge creation by fostering culture for trust among knowledge creation team members (Hislop, 2009; Hofstede, 1980; Schein, 1985).

(5) The structure needs to be designed to elicit all ideas regardless of one's own judgment on ideas. An individual may not propose new ideas thinking that his/her idea is not worthy for a new product or service. As a result of not proposing ideas, the organization may miss potential good ideas (Weick, 1977; Whiteman, 2013).

(6) The structure needs to be designed to select good ideas and get things done (Giddens, 1984; Weick, 1977).

(7) The structure needs to store all proposed ideas for organizational members to provide an opportunity to combine them to create a new idea or for later uses (Kogut & Zander, 1992; Nonaka & Takeuchi, 1995).

(8) The structure needs to be open to generate new competencies with other organizations (Chesbrough, 2003; Madhok, 2002; Schiuma, 2009).

(9) The process of acquiring the state-of-art knowledge needs to be placed so that the organization will constantly acquire all relevant knowledge from science communities, stakeholders, and competitors (Brown & Duguid, 1991; Grant, 1996; Nonaka, von Krogh, & Voelpel, 2006; Spender, 1996).

Once an organizational structure is established to include these factors, individuals will become consciously observing changes in consumers' preference, new discovery of scientific knowledge, and new technology development in the field (changes in economic environment). Individuals become more reflexive and cognizant to what they observe and experience.

4.2. Knowledge creation model

Organizations create knowledge and convert the knowledge into organizational competence; individuals in organizations create knowledge. Felin and Foss (2006) introduce a new framework where the micro-level explanation improves on the collective-level explanation using Coleman's (1990) framework as a tool. Felin and Foss (2006) argue that the theory relies on individual factors, and potential intervention occurs at the individual level. They show one example of capabilities development by the hiring of particular individuals from other organizational settings (Song, Almeida, & Wu, 2003). The model used in our paper is adopted from Felin and Foss's (2006) framework as shown in Figure 1.

Structures enable and constrain actions and interactions of individuals. In Figure 1, the knowledge creation structure affects individuals 1 and 2. Individuals are affected by mission, culture, and leadership in the organization and take purposeful and strategic actions to enhance their utility, forming dispositions to navigate structures (Bourdieu's habitus). Individuals further develop dispositions for

enhancing their knowledgeability in organizational structures as well as organizational environments. Therefore, knowledge creation is dynamic and in motion and scholars developed dynamic capabilities models for knowledge creation and new product development.

5. Dow's business case: Idea Central

Argote and Miron-Spektor (2011) point out that experience interacts with the context to create knowledge. They categorize the context into two categories: organizational and environmental. We adopt their framework with some modification as shown in Figure 1. According to Argote and Miron-Spektor (2011), the organizational context includes structure, culture, technology, identity, memory, goals, incentives, and strategy. The environmental context includes outside of the organization such as competitors, clients, institutions, and regulators. We discuss the Dow Chemical Company's knowledge creation from the organizational and environmental context.

The Dow Chemical Company is a leading knowledge creation and innovation driven firm in the world. The Dow Chemical Company has customers in 180 countries and had annual sales over $57 billion in 2013. The company employed approximately 53,000 people worldwide and has more than 6,000 products manufactured at 201 sites in 36 countries across the globe.

5.1. Internal knowledge mobilization (organizational context)

Knowledge creation structures today converge more easily because of the globalization of the world economy as well as ICT. The currently emerging knowledge creation structure, called "ideation," is defined as "the process of generating or conceiving ideas and concepts that may be useful for attaining some desired state or outcome". Simpson (2008) defines it more simply and concretely: "Ideation is the systematic search for targeted opportunities, and new markets, and new services" (p. 1). Park et al. (2011) have illustrated typical processes that knowledge creating companies follow in developing new competency.

The Dow Chemical Company has established an Idea Central, which is a database. The Idea Central at the Dow Chemical Company includes both the organizational and environmental contexts. When an employee or a group of employees has an idea, he/she can post it to the Idea Central. All employees are encouraged to propose ideas. Dow believes that no ideas are bad ideas; it creates the culture that all ideas are appreciated and valued. Employees who work for Dow learn from their daily experiences in dealing with customers and suppliers or in their labs. Dow obtains tacit knowledge from them and from all functions, ages, and regions in the world, since it is a global company. Variations and diversity of ideas are crucial sources of knowledge creation because they can be combined to create new knowledge. Therefore, Dow management encourages employees to express diverse ideas and create an environment for diversity. The variations in experiences by Dow employees in all functions, regions, and ages are key sources of knowledge creation.

Tacit knowledge is a prime source of new knowledge creation, as Polanyi (1966) argued. Tacit knowledge is acquired through lived experiences and employees receive intimation from the realities of their daily job. Tacit knowledge of their experiences can be momentarily realized, but will be lost if employees do not capture it at that moment. The process of Idea Central helps employees capture tacit knowledge. When the Idea Central is placed in the organization, employees develop dispositions, as Bourdieu (1977, 1990) advocated. The Idea Central of Dow Chemical is also a device to utilize dispersed knowledge (Hayek, 1945), since Dow's employees are dispersed around the world.

5.1.1. Screening

Screening at Dow Chemical is done on a monthly basis. A cross-functional team consisting of four or five members from various functions goes through all proposals posted in the Idea Central. This team makes judgments on ideas, based on deeper analysis of diverse proposals placed by employees from all over the world. The team initially selects the 10 best proposals from the Idea Central and then narrows the list down to a few ideas for funding. Dow saves all proposals for future use.

Some proposals may not be buyable at the time of screening, but they may become value generating ventures in the future, as the economic environment changes (e.g. technologies and market conditions). Since all proposals are stored in the Idea Central and they are accessible by Dow employees, the Idea Central serves as effective organizational memories. Therefore, costly knowledge assets that Dow created are not lost "on the spot," and the Idea Central mediates the problem stemming from the lack of coherence, over time decision-making raised by Nonaka et al. (2006). Dow can also make use of knowledge assets stored in the Idea Central by combining with future proposals for creating new products, processes, or services. Screening can be regarded as a validation process of new knowledge because knowledge is "verified true belief." Although knowledge is abundant making use of knowledge for new competency creation requires resources. Due to the resource constraints, managers need to make choices among alternative knowledge domains and screening at Dow is a process of identifying the knowledge assets value drivers. Identifying the knowledge assets driver is crucial for the organization's value creation. Carlucci and Schiuma (2006) draw the attention on the same point that managers need to better understand how they can identify and evaluate existing knowledge resources within an organization, and how to manage them in order to achieve competitive advantage. Schiuma (2009) also argues that the knowledge assets value drivers represent the key strategic resources that most significantly drive organizational value creation against targeted value propositions (p. 293). Dow has the ongoing formal process of identifying the knowledge assets driver referred to as the Idea Central.

5.1.2. Screening model

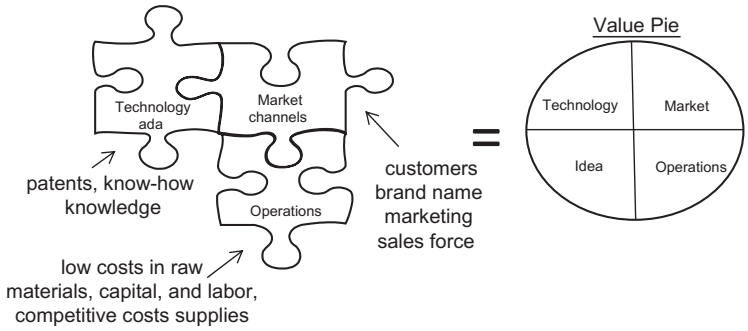
The way that Dow Chemical screens proposals is interesting. Dow's screening method is like putting pieces of a puzzle together. Dow maintains that sustained profitability of any business is only possible with all three advantaged positions. The first piece of the puzzle is technology advantage. Does Dow have a patent or patents for the proposed idea? Patents that need to be evaluated are composition, process, and application patents. If they do not have them, they need to solve that puzzle by contacting patent holders for license agreements or a joint venture. The second piece of the puzzle is operations advantage which includes low-cost raw materials, low capital options, process experience, synergistic cite, supply chain, and regulatory constrains such as environmental health and safety regulations. They assess raw material requirements as well as accessibility of required raw materials and facility and capital. Costs of acquiring them need to be competitive. The third piece of the puzzle is market channels, which includes customers, brand names, reputation, synergistic sales, channel partners, market sales forces, and meeting requirements of regulatory agents such as Environmental Protection Agency and Food and Drug Administration.

5.1.3. Screening procedure

There are smaller puzzle pieces within the three large pieces. In assessing each piece of the puzzle, limitations or constraints are analyzed. If Dow is missing technology pieces, they may develop them within the organization or acquire them from outside. Dow needs to assess the availability of raw materials, facility, and capital as well as missing pieces of the operations puzzle. When they find missing pieces (constraints) they have to solve them. The market channel piece of the puzzle is figuring out customers, brand names, and sales forces. They also examine market penetrability; some markets are very difficult to penetrate because newcomers have insurmountable barriers to overcome. When all the missing pieces of the puzzles are found, they put them together to create value for Dow. Dow will benefit from the entire value pie when Dow put together all pieces of the puzzle. Figure 2 is a graphical presentation of this screening process and value creation. This process may be seen as what Carlucci and Schiuma (2006) referred to as the knowledge creation map.

Once Dow has established the new competency at a competitive level, competitive advantage depends on recognizing new business opportunities and recombining these capabilities and unexploited proposals at the data central as emphasized by Helfat et al. (2007) and Argyres (2011). Argyres argues that "organizational economics can offer insights into features and processes that can promote or hinder opportunity recognition within organizations" (p. 1141). According to Argyres,

Figure 2. Screening process.



"governance choices are endemic to any capability development process, because such processes involve structuring incentives, allocating authority, and stimulating information flow" (p. 1142). Structuring incentives and allocating authority can influence knowledge creation and sharing knowledge.

It is hard to make judgments about what pieces of the puzzle can or cannot be found, and even if the pieces are found, the cost structure may not be competitive enough to embark on the project. They learned the hard way not to waste time and resources for a project that has missing pieces, or is too costly or impossible to find. Appropriate structures are established based on experiences of failures to prevent future failures. This establishment of structures is an example of the realization of theories of Giddens' structures and agents (1984) and Bourdieu's reflexive feedback and self-monitoring (1977, 1990). Therefore, the knowledge creation process is emerging and ongoing, as Whitehead advocated (1929). This process also supports the proposal made by Spender (1996) that knowledge is the basis of a dynamic theory of the firm.

5.1.4. Incentives

The intervention of managers to create knowledge can be made at both institutional and individual levels (Abell, Felin & Foss, 2008). First, managers need to provide opportunities for agents to interact. Managers and individuals together design an institution to be conducive for dialog and interactions. Second, for diversity of ideas, managers need to hire individuals from many different universities and institutions and provide incentive systems for individuals and groups to acquire and share knowledge. When agents acquire useful knowledge (genotype) and skills, firms develop technology (phenotype) based on useful knowledge and knowledge sharing (intensity of knowledge), as Mokyr (2000) argues. When agents accumulate more knowledge and develop dispositions of imagination and creativity, the firm will have easy access to knowledge and creativity (Mokyr, 2000) because knowledge is stored in agents who supply knowledge and skills to the firm. Therefore, developing an incentive system for agents to constantly acquire knowledge and skills is crucial in building the dynamic capabilities of the firm. Individuals' choice of the organization, and their acquiring and sharing knowledge, depends on firm characteristics. As discussed before, structuring incentives and allocating authority are important in knowledge creation and sharing.

Because managers at Dow appreciate diversity and create a culture for employees to supply many different ideas, it rewards those who produce the most ideas as well as the best ideas.

5.2. External knowledge mobilization (environmental context)

5.2.1. Collaboration

What can Dow Chemical do with ideas when they cannot overcome constraints or find missing pieces of the puzzle? Dow figures out factors that the company is missing in the puzzle. Dow then decides to make them internally or to fill them from outside. They license out (sell) ideas to those who have the capabilities to use them or form a joint venture. Dow Chemical searches for a firm that needs the

knowledge that Dow has and negotiates a license agreement. A joint venture agreement is another solution for utilizing their ideas. They form a joint venture by connecting a network of companies which have pieces of the puzzle (technologies, ideas, and operation). They can find small companies who have good ideas or Dow's missing puzzle pieces and establish joint ventures. This example shows that innovation capabilities are distributed across firm boundaries, and managers combine distributed innovation capabilities to create a new capability through structures which coordinate the contributions of the various participating firms (Coombs & Metcalfe, 2002). Coombs and Metcalfe (2002) argue that we need to consider how the capabilities perspective can be extended to embrace a multi-firm perspective on innovation. They further argue that capabilities themselves become an important unit of analysis which is not coterminous with the firm. Madhok (2002) points out that "the reasons for collaborations between firms is to combine synergistically two sets of complementary but dissimilar resources and capabilities in a manner which will generate returns that will either create a market transaction or complete internalization" (p. 277). Dow Chemical recognizes that advantages frequently occur in different organizations. Therefore, collaboration is critical because each organization has a unique pile of "advantaged" puzzle pieces. There are many possibilities in finding matches with other collaboration partners who have technology, operations, and/or market advantage that Dow Chemical does not have. Dow can buy, sell, create, and trade pieces with collaboration partners. Possible collaborations partners are universities, large companies, small and start-up businesses, market specialists, and incumbents. Finding optimum partners is crucial for the success of collaboration. Dow has developed good strategic mixes for acquiring advantage in collaboration (Whiteman, 2013). The practices of Dow's scouting, collaboration, and joint venture can be regarded as an open innovation system (Chesbrough, 2003). The openness of technology sharing economizes costs in new product development by accomplishing the economy of scale and scope as Chesbrough (2003) argues. According to Chesbrough (2003), open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. We can see that Dow's practice is a good example of open innovation.

However, the cross-firm structures for new capabilities innovation need to address governance issues on opportunism. Firms need capabilities to write contracts that efficiently deal with opportunistic behavior. Joint ventures among many firms require trust among the participating firms. Past experiences help build trust and reputation within the industry. Once a firm is known for taking advantage of participating firms and not sharing ideas, other firms are likely to avoid future joint ventures. Building a good reputation can be a strategic asset in the long run because business dealings are ongoing and repeating. Once the value pie is created, they split it based on contributions or strengths of each participant (see Figure 2 for a value pie). The initiating or proactive company can secure a better share of the value pie. This example shows that the governance choices of the firm (Argyres, 2011; Williamson, 1991, 1999) are involved in any capability development.

Dow forms over 100 joint ventures in a year, and having good intuition for what consumers would like to have is a key factor for success in joint ventures, as well as in Dow's new product development. Firms can search to find an addressable market and its size and explore market needs based on voices of customers (VOC). As von Hippel (1988) indicates, customers and suppliers are the most important sources of innovation. VOC provide information on market needs. However, managers' intuition on what consumers want plays a key role in the success of a new product. The cofounder of Apple Company, Steve Jobs, was known for his good intuition on consumers' preferences and Steve Jobs and his designer, Ive, worked to simplify new design. Apple's first brochure proclaimed "Simplicity is the ultimate sophistication," and Steve Jobs had aimed for the simplicity that comes from conquering complexities, not ignoring them (Isaacson, 2011, p. 343). Samsung (a Korean chaebol) is taking a different track and values consumers' knowledge and experiences (Chen, 2013, February 11). Knowledge about what consumers want is a hidden reality and managers/knowers capture intimation from that hidden reality. Their intuition is a key element for the success of a new product. Dow's success rates are known to be 20–30%. This example shows how the network form of organization emerges as an adaptation to changes in the environment for knowledge creation (Hannan & Freeman, 1984; Levinthal, 1997).

Dow Chemical's practice for new product development illustrates an integration of macro–micro approaches. The Idea Central (macro level) structure is designed to solicit tacit knowledge from individuals (micro level). The variations in knowledge creation structures among organizations may have a different impact on individuals, and individuals' responses to the same structure may differ based on personal traits. If an Individual's ideas are verified by a team and the project proposed by an individual becomes a new competency by team efforts (meso level), interactions among individuals result in new qualities on the macroscopic level of the system (Fuchs, 2003). Interactions among individuals from cross-functions lead to new knowledge and competency creation in Dow. Variations of ideas offer opportunities for the organization to recombine them for new competency (Kogut & Zander, 1992, 1996; Nonaka, 1994; Nonaka & Takeuchi, 1995; Schumpeter, 1934). This example of Dow's knowledge creation illustrates how to engage in knowledge creation activity and how this knowledge evolves over time (Levinthal, 2006; Winter, 2006). Dow Chemical's Idea Central can be seen as a ba (a knowledge creating place: Nonaka & Konno, 1998; Nonaka, Toyama, & Konno, 2000; Nonaka et al., 2003). Bas may vary depending on the contexts of knowledge creating firms and the market selects a good ba and the selected ba retains good characteristics of the ba. Variations in knowledge creating bas will continue in the market and the knowledge creating firm is, therefore, dynamic. According to Nonaka and Toyoma (2003), ba can transcend time, space, and organization boundaries to create knowledge. A knowledge-based view of the firm regards the firm as a knowledge creating entity and a firm in this view is changed from an entity of being to an entity of becoming (Nonaka & Toyama, 2002, 2003) as seen in Prigogine's scientific view of the world (2003).

Collaboration saves precious time in developing new products, processes, and services. Collaboration may be a better practice in a high-velocity economic environment because firms can bring new products to the market quickly. Nonaka, Toyama, and Nagata (2000) point out that building one's own knowledge comes with cost, i.e. time. Building up knowledge assets through a firm's own knowledge creating process takes time, and hence costly (Nonaka, Toyama, & Nagata, 2000). Teece (2007) argues that the opportunity cost is especially high when the industry that the firm is in is a high velocity economic environment. If the firm develops the missing puzzle pieces by themselves, they may fall behind the market competition.

5.2.2. Scouting

Scouting is seeking knowledge from external source for Dow Chemical. Dow Chemical has several scouting departments whose jobs are obtaining knowledge from outside sources such as academic journals, conferences, universities, and government agencies (NIH). Employees in a scouting department also search out information and knowledge from suppliers, customers, and competitors. This process may be regarded as identifying stakeholders' knowledge assets (Schiuma, 2009). Dow Chemical arranges agreements with those who have patents, if the patent is deemed necessary for Dow. Scouting, designed to obtain knowledge from outside of Dow Chemical, is divided into many different specialties, such as engineering and science, and acquires external knowledge from various sources (see Figure 2). This knowledge creation practice of Dow provides evidence of Nonaka and Toyoma's (2003) boundary crossing. Chesbrough (2003) refers to this as the open innovation system which is the use of purposive inflows and outflows of knowledge to accelerate innovation. Chesbrough (2003) argues that open innovation saves time and costs compared to closed innovation.

External sources of knowledge have been gaining importance in the knowledge economy. Apple Company, for example, is known for offering strong incentives to small companies and individuals with new knowledge. If knowledge from external sources is adopted in Apple products, a significant portion of the additional profit generated by adopted external knowledge is offered to the firm or the individual who supplied the knowledge. This is a strong incentive to the supplier of knowledge because Apple Company has a large market and this creates value for both Apple and knowledge suppliers. Apple Company acquired multi-touch sensing capabilities from FingerWorkks (Isaacson, 2011) and

Google acquired Android. Examples of the Dow Chemical Company, Apple Company, Google, and Samsung illuminate that organizations are utilizing internal and external knowledge for new competency development.

6. Discussion

This paper develops a knowledge creation model which incorporates both the structure and individual levels, providing a relatively more complete picture of the knowledge creation process at the workplace. We proposed a knowledge creation model that includes factors that are conducive for knowledge creation and examined relationships between the structure and individual agents in knowledge creation.

The Dow's Idea Central is a structure of a new competency creation. The Dow Chemical Company acquires knowledge from individuals and teams from within the organization and external sources. The Idea Central at the Dow Chemical Company includes all factors conducive for knowledge creation. We found that individuals at the Dow Chemical Company are encouraged to propose all ideas; Dow recruits its employees from diverse backgrounds and universities for diversities in ideas; knowledge creation teams consist of people with diverse experiences and trainings and team members interact and share knowledge. Dow's structure for mobilizing internal knowledge is the Idea Central and its structure for mobilizing external knowledge is collaboration and scouting. Scouting consists of several fields such as sciences and engineering. Incentives at the Idea Central are primarily intrinsic in nature and nonmonetary rewards.

The Idea Central (structure) at Dow elicits knowledge from individuals and Dow's employees develop a disposition for being more conscious in observing new development in consumers' preferences and changes in environment.

The Dow Chemical Company case is a knowledge creation and new product development practice of a firm. The case illuminates how a company manages knowledge to develop a new product and provides a knowledge creation model which offers an opportunity to assess a knowledge creation model. The Dow Chemical Company formed the Idea Central as an organizational structure for identifying and exploiting internal and external knowledge assets in new competency creation, created conducive culture for knowledge creation, and used information and computer technology. Dow has made changes in structure based on the conscious feedbacks of stakeholders as proposed by scholars (Bourdieu, 1977; Coleman, 1986, 1990; Giddens 1984; Whitehead, 1927).

7. Conclusions

This paper examines the structure–agent approach in knowledge creation. As firms design structures to create knowledge, individuals develop a set of dispositions in response to these structures. Thus, structures influence individuals, and based on these structures, knowledge outcomes may depend on individuals' actions, interactions, and creativity.

The Idea Central at The Dow Chemical Company is the knowledge creation structure to elicit tacit and dispersed knowledge from employees, stakeholders, and competitors. The Idea Central continues to change as knowledge creation teams reflect and consciously self-monitor structures and knowledge outcomes. As actions and interactions of members in knowledge creation teams generate nonlinear knowledge outcomes, individuals in such teams tend to develop dispositions to acquire new knowledge through their work experiences and interactions with stakeholders. When they become conscious of knowledge creation, the reflexive self-monitoring employees in today's knowledge economy are valuable in both knowledge creation and changing organizational structures.

Therefore, we conclude that the Dow's Idea Central is reasonably well-structured structure that includes crucial factors for knowledge creation.

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